TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XIV, No. 3. MARCH, 1937. PRICE 6d.

CONTENTS.

	PAGE.
Soil Conservation in the Tropics	57
Banana Leaf Spot	59
Rejuvenating Old Rubber Trees	60
A Portable Scale for Experimental Work	61
Recent Investigations on Sugar-Cane and Sugar-Cane Soils in Trinidad	63
Citrus Scab on Marsh Grapefruit	69
Tropical Fruits and Vegetables	70
Nutrition Studies with Corn	83
A New Disease of Cacao in the Gold Coast	84
Reviews	85
The Cacao Industry of Trinidad	87
Sugar Notes	90
Chemical Notes	91
Trend of the Markets	92

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C.3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

SOIL CONSERVATION IN THE TROPICS.

"The wages of agricultural sin is soil impoverishment."

THE opening sentence of Professor Bailey's introduction to that classic "Farmers of Forty Centuries" (1) states that the first condition of farming is to maintain fertility, a maxim that for all its importance is too often overlooked. The farming industry of any country must hold the balance accurately between incomings and outgoings, for if the latter exceed the former, the end is only a matter of time. Surprising differences are found when one makes a general survey of the farming systems that obtain in different parts of the world in their relation to the maintenance of soil fertility. All systems of course live on their capital to the extent that they draw on the stores of plant food in the soil, but where fertility is maintained at a steady level, this is not done at a rate faster than these stores are rendered available.

The most criticised of all systems of tropical agriculture is that practised by the great majority of African peasants, and known generally as 'shifting cultivation'. The details of this system vary widely in different parts of the tropics, but may be briefly described as a prolonged rotation, comprising two or three seasons' cropping followed by a number of years fallow.

As a method of utilising natural fertility the system was in most cases admirably adapted to the conditions in which it was evolved, and much of the adverse criticism which it is fashionable to make on it is based on misunderstanding. It is called by Willis (2) "a vicious mode of cultivation and both wasteful and destructive," but a little consideration will show that, in a country where there is plenty of room, it is the most economical system of utilising the natural gifts of the soil. During the years of rest, the land regains its fertility, and is purged of the weeds of cultivation, so that its cultivation becomes both easy and profitable. A system cannot be deemed wasteful because it does not conserve something that will never be used. As well applaud the economy of a householder who with infinite care saves all unnecessary use of electric current in his house only to find at the end of a quarter that he is considerably below the minimum charge for supply.

These systems of shifting cultivation are now breaking down, owing to the increase of population. A considerable portion of the Heath-Clark lectures delivered by Sir Daniel Hall at the University of London in 1935, and now published in book

form under the title of "The Improvement of Native Agriculture in relation to Population and Public Health"* deals with this problem and the means by which shifting cultivation can be replaced by a more permanent settlement on the land. It is not a matter that can be shelved any longer, for the situation, as described by so many authorities, has already become serious. In spite of the difficulty in effecting a change, and it must be remembered that any change-over from communal to individualist farming implies, among much else, a complete upset of the African view of land tenure, the outlook is not hopeless. It is often said that the native farmer is conservative, but as Sir Daniel remarks it is easy to exaggerate his conservatism, and, after all, one can hardly describe as conservative, a people like the Baganda, who in the last nineteen years have increased their production of cotton from 36,000 bales to 250,000 bales, or who are buying ploughs, an implement quite new to them, at the rate of over 2,000 a year (3).

There are other grounds for hope, for in a few cases a permanent system of agriculture has already been established, and no better illustration of such could be taken than the state of things portrayed by Wakefield (4) in the island of Ukare in Lake Victoria Nyanza. The density of the population on this island is 600 to the square mile, and force of circumstances has brought about an intensive and self-contained system of farming. The cattle are stall-fed, the manure is carefully preserved, and green manuring crops of *Crotolaria* spp. and *Tephrosia* spp. are regularly grown. This density of population is nothing in comparison with the 3,700 to the square mile described by King (*l.c.*) as living in the island of Chung Ming, but is vastly greater than the 15 which is the average of Tanganyika. What one tribe has done, another tribe can at least attempt, and encouragement is here.

Success has been obtained in this case largely by the careful and economic use of cattle, both as a means of power and as makers of manure, and it may here be recalled that the development of a system of mixed farming along these lines figures largely in the activities of the Department of Agriculture in Nigeria. In the large areas which are infested with tse-tse fly and where cattle cannot, in consequence, be kept, recourse must be had to composting, a process which figures so largely in Chinese agriculture, and green-manuring. The latter is limited by climatic conditions, but composting must be an important feature in any self-supporting system of tropical agriculture. A great deal has been written on this subject lately, but few of the views expressed, represent any experimental work, comparing the effects of varying the method of treatment. The Indore system, for instance, recommends the use of pits, but it is doubtful whether these are in most cases necessary or even desirable, for they are not only expensive, but imply the permanency of the composting site. Sir Daniel points out the desirability of utilising in such composts human as well as animal excreta, a development which would enable the African native not only to maintain the fertility of his land, but also to safeguard the sanitary condition of his habitation.

Sir Daniel passes on to the question of over-stocking, for if it is true that in some parts of Africa the farmer is handicapped by being unable to keep stock, it is equally true that in many areas the land is far too heavily stocked, with the result that it is becoming over-grazed and rapidly ruined. The state of affairs was recently vividly described in a trenchant article by Deck (5), until lately Commissioner in the Masai country. The problem has many aspects, since the keeping of cattle is intimately bound up with the social life of many African tribes, but it is no use burking the issue, for it involves the preservation of the very means of existence of many tribes in Africa, and it is disappointing that anyone with Professor Leakey's knowledge of the country should express a contrary view. His statement that "if the policy of the drastic reduction of the numbers of so-called uneconomic animals were blindly enforced, there could only be one result: famine" (5) shows a failure to understand the problem. It is surely better that the Masai should forego a portion of his ration of fresh blood, than that whole tribes should not have any means of sustenance whatever.

To this question of nutrition Sir Daniel devotes a most interesting chapter of his book. He dismisses the picture of the 'magnificent' health of the African native and emphasises the inadequacy of the diets with which the majority of Africans have to be content, and the amount of deficiency disease that prevails. A fuller and better balanced dietary is the remedy, and this can only be obtained by better native farming, and the production of more leguminous crops. "We want", he writes, "an African station in the programme of which the soya bean, the earth nut, the cowpea and the velvet bean would have leading places". The utilization of the milk of cattle and goats would lead to a greater appreciation of the good milch animal, and help to bring about the much-needed improvement in the quality of livestock by methods that have been successful elsewhere (7). Orr and Gilkes (8) conclude their work "The Physique and Health of the African Tribes" by saying "the general improvement of agriculture and animal husbandry amongst the Akikuyu will almost certainly be followed by an improvement in the health and working capacity of the natives themselves".

It is of course, *au fond*, a question of education, and the Administrative and the Agricultural Departments must work together. Sir Daniel scarcely does justice to the latter, for he judges

* Sir A. Daniel Hall, vi + 104 pp. Oxford University Press. 10*s*. 6*d*.

them largely by his Kenya experience, and Kenya is a colony which differs in many ways from the other Tropical African colonies. It is hardly fair to describe the officers of the Agricultural Departments of our African colonies as only incidentally coming into contact with native agriculture for subsistence, nor is it just to say that this side of agriculture has received little attention from them. The writer has occasion regularly to study the programmes of the Agricultural Departments of all our Tropical Colonies, and can testify to the large and increasing amount of work that is being devoted to the improvement of native agriculture in most of them. A certain amount of attention must be given to export crops, whether grown by the natives or not, but this need not, and in most cases does not, overshadow the importance of the food crops.

Sir Daniel ends on a note of hope. He envisages the introduction of a fixed agriculture capable of maintaining indefinitely the producing power of a given piece of cultivated land, which will in turn repair the deficiencies in the native dietary, will raise the standard of living and help to ward off some of the diseases from which natives are now suffering. The burden of the work must fall on the officers of the Agricultural Departments, and it is not the least part of their training here to fit them for the task.

R. C. W.

References.

1. King. Farmers of Forty Centuries.
2. Willis. Agriculture in the Tropics. Camb. Univ. Press. 1914.
3. Dept. of Agric., Annual Report. Part I, p. 15.
4. Wakefield. Mixed Farming and Peasant holdings in Tanganyika. *Empire Cotton Growing Review*, 11, 87.
5. Deck, S. F. *Tropical Agriculture*, 13.
6. Leakey, L. S. B. Kenya: Contrasts and Problems. Methuen & Co., 1936.
7. Wood, R. Cecil Cattle in the Tropics. Imp. Coll. of Trop. Agric. 2s.
8. Orr and Gilkes. The Physique and Health of the African Tribes. *Med. Res. C.*, 1931.

BANANA LEAF SPOT (*CERCOSPORA MUSAE*).

By G. Stahel.

Agricultural Experiment Station, Surinam.

[*Cercospora leaf spot, one of the most serious banana diseases in Fiji and Queensland, has since* 1933 *been spreading in the Caribbean area causing considerable damage in many plantations. Particularly serious outbreaks of the disease have recently been reported in Central America, and the disease is also known to be present in Jamaica. In Surinam, Cercospora, which has been prevalent since* 1934, *has also done much damage. Fortunately for other parts of the West Indies, Dr. Stahel has recently completed a comprehensive investigation on this disease which will be published later in this Journal. As the disease is causing much concern Dr. Stahel has been good enough to send us an advanced summary of his findings which is reproduced below.*—Ed.]

Since 1933, Cercospora leaf spot has been spreading over the banana plantations in the West Indies and Central America, causing considerable losses. Prior to this date, it was known in Fiji and Queensland as a serious disease of bananas. Since 1934, the Surinam banana plantations have been badly infected by this leaf spot. In 1936, I therefore began a study of this disease. This is nearly completed and will be ready for publication in this Journal in a few months. In view of the increasing losses caused by this disease in the West Indies, it may be useful to give here a resumé of the results of my study in anticipation of the definitive publication.

On the experiment fields of the Surinam Banana Company, the bananas have been sprayed twice or thrice a year with Bordeaux mixture since 1934 with much success. The usefulness of spraying, also in respect of economical aspects has now been established by these continued spraying experiments. Spraying is much facilitated on the empoldered Surinam plantations by the fact that the power sprayer can be mounted on a boat, so that every part of the fields can easily be reached.

Hitherto, practically nothing has been known as to the manner of infection by *Cercospora musae*. In devising economical control measures, a thorough knowledge of this aspect was considered strictly necessary.

The fungus enters the lower side of the banana leaf. Infections on the upper leaf surface were unsuccessful or resulted sometimes only in an insignificant infection, even when a concentrated emulsion of Cercospora conidia was sprayed on the leaf.

Only the two youngest leaves are very susceptible to infection. These are the leaves that are generally entirely free from leaf spot, even in a heavily infected field. The third leaf is less susceptible, and on older leaves even an application of a concentrated emulsion of conidia results in a weak infection or in none at all.

The germ tube of Cercospora lives during the first four to six days on the surface of the leaf. Thereafter it enters a stoma and grows along the inside surface of the large air chamber to the palisade tissue. Here the hypha begins to branch, and to grow intercellularly between the palisade cells. This parasitic mycelium however remains scanty all the time. The fungus spreads from here to the neighbouring air chambers between the two nerves, discolouring the palisade tissue into a yellow green. The penetration of the nerves seems to be difficult for the fungus, so that in many cases ripe streaks consist of only one internerval space. In other cases, however, the streak is accompanied by one or two shorter streaks along the sides.

The very first symptom of the disease, minute yellow-green speckles the size of an air chamber, become visible 15 to 17 days after the application of the conidia, or 11 days after the penetration of the stomata by the germ tubes. On the 22nd to 24th day after artificial infection, the yellow green speckles have developed into streaks eight to ten mm. long. At this time they look as if covered by rust.

At this stage the fungus grows out through the stomata of the streak and spreads over the leaf-surface round the streak to a distance of two to three mm., chiefly on the lower side of the leaf. The epiphyllic mycelium has a toxic effect on the underlying leaf tissue, causing guttation and infiltration, followed by necrosis a few hours later. This happens 24 to 27 days after infection. The fungus then immediately enters the dead tissue from the outside through the stomata, and begins to produce small acervuli in the sub-stomatal airchambers on both sides of the leaf. Since the lower leaf side of the Congo bananas has about five times more stomata than the upper side, more conidia are found at this stage on the lower side of the leaf.

The spot may subsequently become still larger by renewed marginal infiltration; further extension of the spot is checked by a broad margin of leaf tissue impregnated with a black gum.

By spreading on the outside of the leaf, the fungus need not penetrate the strong walls formed by the nerves and is soon able to enlarge the primary streak.

After a week or more, the brown spots collapse and form the typical light grey, or sometimes light brown, dry centres seen in older spots. Here only the acervuli of the upperside continue to enlarge and to reproduce conidia.

Between the acervuli, Leptosphaeria perithecia with 4-celled spores, and Hendersonia pycnidia with five (four to six) celled spores appear regularly. In pure culture, both Leptosphaeria and Hendersonia spores produce exactly the same mycelium, this being entirely different from that of Cercospora. The two fructifications belong to the same saprophytic fungus constantly present on the spots even in Australia.

There are also two other fructifications permanently found on the dry centres: spermogonia and minute perithecia, with only one to two asci, belonging to the genus Mycosphaerella. It could be conclusively shown that the spermogonia belong to Cercospora. In pure cultures, the mycelia of Mycosphaerella are of the same compact and slow growing type as the Cercospora mycelia. When compared, however, with Cercospora mycelia of a strain, isolated eight months before, they could be distinguished one from the other, but the difference is not great and more quantitative than qualitative. Accordingly, Cercospora mycelia from conidia and primary streaks are again being isolated. It seems to me probable that the freshly isolated mycelium will be identical with that of Mycosphaerella.

As a rule two outbreaks of the disease can be observed in Surinam, one in February and one in July: this means in the third month of the short as well as of the long rainy season. They are the result of an accumulated infection of about four to five weeks earlier. If therefore the lower surface of the two or three first leaves is covered with a fungicide in December or January and in May or June, spraying may have the greatest effect under Surinam conditions.

Probably the growth of epiphyllic mycelium and the formation of the brown spots may also be prevented by the fungicide. In this case, even the fourth leaf will have to be sprayed. Experiments in this direction are in progress.

In heavily infected fields the protection of the lower side of the two or three youngest leaves, grown after the spraying, may substantially be supported by a stripping of the older badly spotted living leaves, the source of infection. If a very heavy infection has to be stopped, the application of the fungicide may be repeated 15 to 20 days after the first spraying when two to three new leaves are formed. At the same time, the stripping has to be carried out rigorously. According to the severity of an expected outbreak, and to economical considerations, one has to decide in each case which control measure or combination of measures should be applied.

REJUVENATING OLD RUBBER TREES

Although for some time past inorganic fertilizers have been successfully used for young *Hevea* trees, of late they have scarcely been used at all for old or deteriorated stands, partly owing to the economic depression in the rubber world, and partly because many planters were not convinced that it 'paid to fertilize'. During these last five or six lean years, however, Dr. W. B. Haines, of Dunlop Plantations, Ltd., and E. Guest have been conducting a series of large-scale experiments on the manuring of *Hevea* in Malaya, and have arrived at some important conclusions (*Empire J. Exp. Agric.*, Oct., 1936). These authors give 'chapter and verse' for their conclusion that the primary need of old or deteriorated rubber trees is nitrogen; young trees, however, mostly need 'minerals' as well. Response to manuring with nitrogen (4 lb. of sulphate of ammonia per tree) usually occurs in two stages. In the first, which is associated with improved foliage, the yield of latex increases by about 10 per cent.; in the second, associated with improved bark renewal the increase in yield averages about 35 per cent. but does not begin until the second or third year after the initial application. As a rule, it does not pay to apply nitrogen unless the latex-yield has fallen below 400 lb. per acre; and it is suggested that the best criterion of the need of nitrogen is given by the growth rate of the tree: when the annual girth-increment has fallen to, or below, ½ inch per annum, quick response to nitrogen may be confidently expected. The authors also review past experimental work, and discuss problems related to manuring, such as the use of cover crops and *Oidium* leaf-disease.—(*Nature*, Vol. CXXXVIII, No. 3500, p. 936, 1936.)

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

ACADEMIC STAFF AND STUDENTS 1936-37.

Sitting left to right:

1st Row.—K. G. Proverbs, L. H. Lord, J. D. Lenagan, P. J. Sauvage, M. S. Sampath.

2nd Row.—C. T. Watts, J. R. Dickson, J. G. Davies, G. G. Gianetti, C. Y. Shephard, F. Hardy, Sir Geoffrey Evans, R. C. Wood, E. E. Cheesman, A. M. Adamson, C. W. Wardlaw, D. D. Paterson, D. W. Duthie.

Standing left to right:

1st Row.—A. B. Lucy, W. E. T. Bond, A. P. S. Forbes, A. F. Posnette, R. G. Fennah, G. R. Langdale, N. Wright, O. J. Voelcker, R. E. D. Baker, E. R. Leonard, B. de L. Inniss.

2nd Row.—W. Ryle Davies, W. G. Stuart, J. G. Smith, O. C. Henriques, R. S. Patel, E. F. Allen, A. C. Gomez, D. H. Welch, E. L. Hay, M. Akenhead, D. M. Hanschell, G. D. Badger, E. P. Schonbeck, R. F. Innes.

3rd Row.—J. Huc, W. A. Flook, C. M. Salazar, E. D. Weller, D. P. S. Delgado, H. T. Foster, D. M. Khandke, B. N. Ray, I. Hosein, W. R. E. Nanton, D. L. Foster, E. R. H. Martin.

4th Row.—H. H. Beach, O. F. Churaman, H. T. Carrington, T. Chinloy, F. O. Gonzales, D. M. ffrench-Mullen, R. T. Hernandez, W. A. Rose, K. M. Houlder.

Absent:

G. A. Jones, C. C. Skeete, P. E. Turner, A. L. Corbin, H. V. M. Metivier, A. O. Harris. C. G. Munro.

A PORTABLE SCALE FOR EXPERIMENTAL WORK.

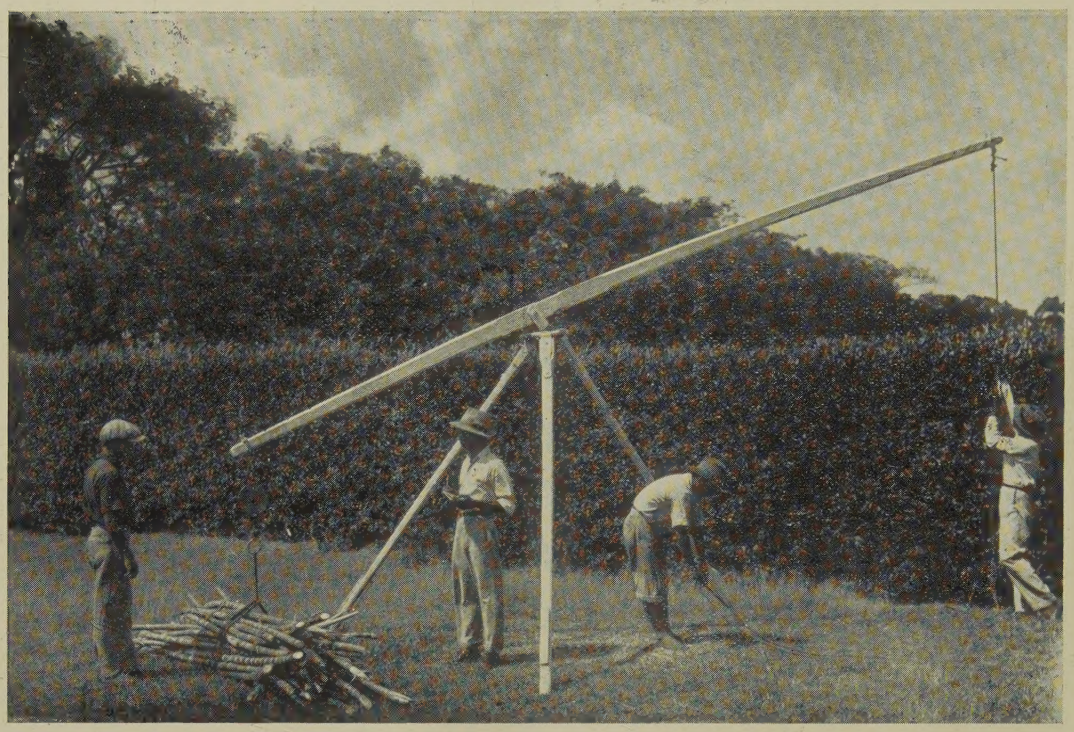


FIG. 1.—*A slingful has been made up and the scale hooked preparatory to raising. Another sling is being set on the ground to accommodate the fetchers.*

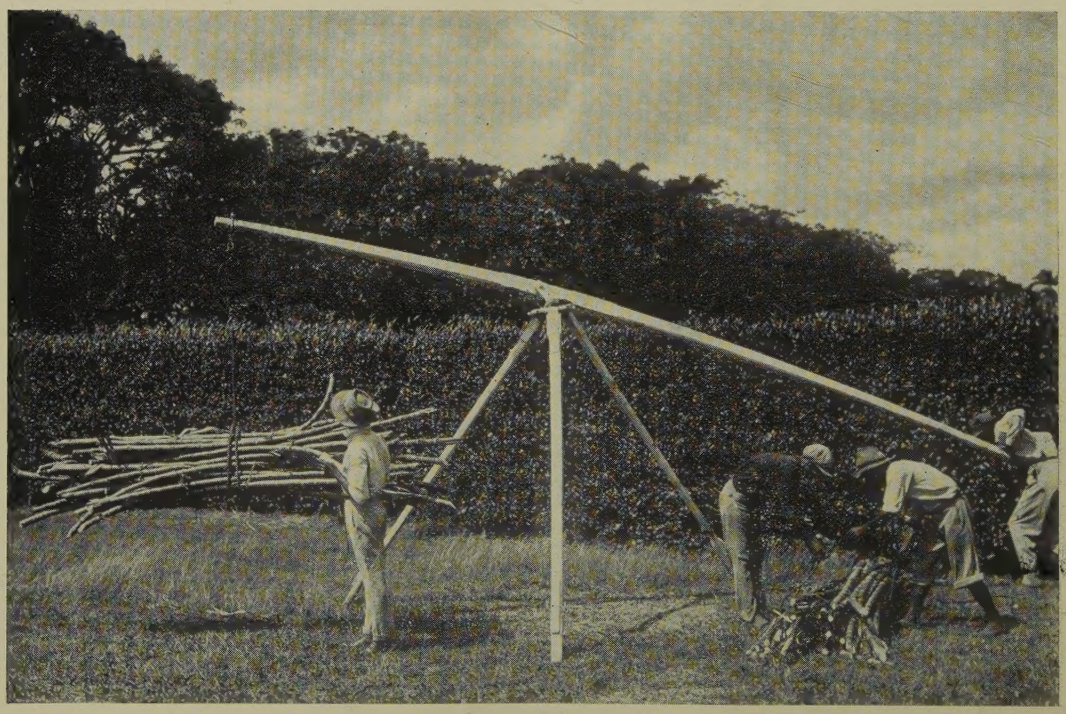


FIG. 2.—*While the foreman notes the weight of the suspended cane, another sling is being made up. The weighed cane is swung around and dropped at the back of the machine and the scale moves on to take up the next slingful.*

A PORTABLE SCALE FOR EXPERIMENTAL WORK.

By C. Holman B. Williams,
Department of Agriculture, British Guiana.

British Guiana cane fields are surrounded by canals and it is not feasible to use carts or portable track in the field. In consequence, cane cutters arrange the cut stalks in bundles which eventually have to be carried out from the interior of the fields to the peripheral beds (known locally as dam beds) whence the cane is loaded into flat-bottomed steel barges, or punts, for transport to the factory. The distance such bundles are carried on the head will vary from a few feet, for the canes near the dam beds, to 75 yards. The weight of the bundle is averaged by each cutter to suit his strength (his greatest difficulty is in raising it alone rather than in carrying it) and may vary from 50 to 130 pounds. The cane for each bundle is placed on a "cane band" (the top portion and crown of leaves of a cane stalk, the leaves being knotted together at their distal end) which is used to tie the canes together at lifting.

At the initiation of intensive field tests in British Guiana, a few years ago, an attempt was at first made to weigh the cane of each plot *in situ* and then leave it to be fetched out. It was found, however, that this involved double bundling (once for raising the cane to put it on the scale and again for raising the cane to take it out to the dam beds) and considerable delay.

At Blairmont estate, however, a satisfactory machine was developed for weighing the cane as it is brought out to the dam beds and this, with slight modifications, has been adopted by the Sugar Experiment Station and is working admirably.

Since others working with cane or similar crops may find the machine useful, it is described and illustrated in the present article. As will be seen from the photograph, it consists essentially of a tripod, acting as a fulcrum, lever-arm and spring balance.

The feet of the tripod are made of strong wood such as 2″ × 4″ Mora. The cleats nailed near the end of the feet prevent them from penetrating too deeply in the soil when this is moist.

The crown plate for the tripod is of ¼″, the hinges of ⅛″ sheet iron. It is an advantage to have detachable hinges, the bolt holding them in place being secured by a split-pin.

The lever-arm is made of 5″ × 4″ greenheart or other tough timber. At its long end is a U-bolt with a ring attached. A 25-ft. length of rope, fastened to this ring, serves to pull the lever-arm down after the short end has been hooked to a slingful of cane. At the short end of the lever-arm are another U-bolt and ring. Fastened to the latter is a spring hook for the scale which is only put on after the machine has been set up. The jaws of the clamp on the lever-arm are made of 5/12″ iron, while the pin which fits into the crown plate of the tripod is 1¼″ in diameter. A split-pin or nail is fitted to this pin when the lever-arm is in position on the tripod.

A suitable scale which stands up well to the rather rough handling it receives is Salter's Spring Balance (Silvester's patent) weighing up to 300 lb. by 1 lb.

The rope used for hauling down the lever-arm and for the cane slings is half-inch manila. Four slings per scale are provided. This allows for one on the ground on either side of the scale for taking canes, one being unloosed in the heap of weighed cane and an extra one in case of breakages. To make a sling, a length of 12 ft. of rope is spliced. A sling of this size will take from two to four bundles as brought out by the cutters. When enough cane is on it, one end of the sling is passed through the other and hooked to the scale. The lever-arm is hauled down and the weight noted. The sling-load is then swung out of the way (by walking around with the lever arm) and lowered so that the sling may be unhooked and pulled out from under the cane.

Four men are employed on each machine; one literate, experienced lad from the Experiment Station who directs operations and notes the weights, and three labourers. One labourer is stationed at the long end of the lever-arm, the other two set, shake up, hook and unhook the slings. Such a team will weigh six-plant cane plots of one-twentieth of an acre (a total of 15 to 20 tons of cane) in an average day, taking the cane from five cutters as fast as they can cut and fetch it out. Where cane can be weighed on the plots the scale will do a great deal more.

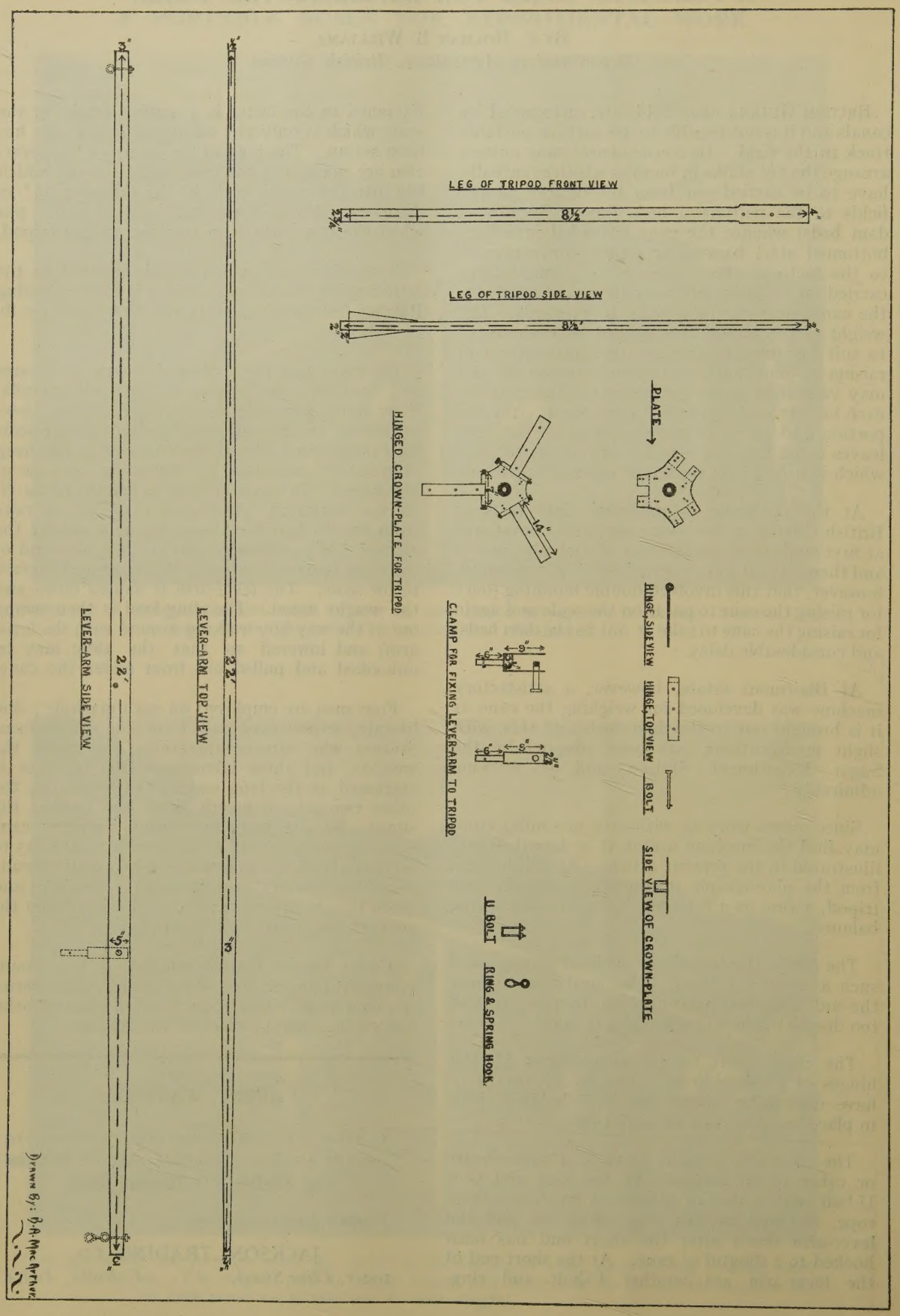
Under British Guiana conditions, it is found convenient to use five or six scales in harvesting a given experiment, one Field Assistant being placed in general charge of the reaping.

AGENT WANTED.

A FIRM OF LONG STANDING DESIRES TO APPOINT AN AGENT FOR THE SALE OF **Gunnies** AND **Shellac** AND **Hessian Cloth.**

Further particulars from :—

JACKSON TRADING Co.,
102-1, *Clive Street,* *Calcutta, India.*


LEG OF TRIPOD FRONT VIEW
8½'
LEG OF TRIPOD SIDE VIEW
8½'
PLATE
HINGED CROWN-PLATE FOR TRIPOD
14"
CLAMP FOR FIXING LEVER-ARM TO TRIPOD
HINGE, SIDE VIEW
HINGE, TOP VIEW
BOLT
SIDE VIEW OF CROWN-PLATE
U BOLT
RING & SPRING HOOK
LEVER-ARM TOP VIEW
22'
LEVER-ARM SIDE VIEW
22'
Drawn By: D.A. MacArthur

RECENT INVESTIGATIONS ON SUGAR-CANE AND SUGAR-CANE SOILS IN TRINIDAD.

III.—Effects of Manurial Treatment with Ground Limestone on Crop Quality and Yield of Commercial Sugar.—*Concluded.*

By P. E. Turner,
Sugar Agronomist to the Department of Agriculture, Trinidad.

Effect of Size of Dressing of Lime on Yield of Available and Commercial 96° Sugar.

The yield of available 96° sugar and of commercial 96° sugar on the plots of the various experimental areas have been calculated according to a procedure described by Davies (11), a standard series of conversion factors, based on local factory experience, being used throughout. A purity correction of 2.2 has been applied to reduce the recorded (small mill) values for juice purity into the 'normal' values. A mill-extraction factor of 94 per cent. has been taken as representative for the conversion of 'sucrose in cane' into the form 'sucrose in juice expressed as a percentage of the weight of cane'. Winter's factor* has been used to calculate the amount of 'available' sucrose in juice per cent. cane from the amount of sucrose in juice per cent. cane. To convert available sucrose in juice per cent. cane into available sugar in juice per cent. cane the recovery in the boiling house (B.H.E.) has been taken as 99.5 per cent. Available sugar in juice per cent. cane has been converted into available 96° sugar per cent. cane by dividing by 0.96. Multiplication by the yield of cane then gives the yield of commercial 96° sugar.

* Winter's factor $= 1.4 - \frac{40}{\text{Purity of normal juice}}$

Plant Canes.

Data relating to the effects of size of dressing of ground limestone on yield of plant canes and of available and commercial 96° sugar under the range of ripening conditions which obtained in Experiments V, IV, and XIV are recorded in Table XIII.

Table XIII.—*Effect of size of dressing of limestone on yield of 96° sugar. Plant canes.*

Experiment V.—Conditions very favourable to ripening. Variety B. 156.

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Gain per cent.	Amount tons per acre.	Average gain per cent.	Yield tons per acre.	Gain per cent.
Nil	11.64	—	30.73	—	3.58	—
½ L.R.	11.85	+1.80	33.19		3.89	8.7
L.R.	11.67	+0.26	32.17 } 32.86	6.9	3.86	7.8
1½ L.R.	11.42	−1.89	33.23		3.76	5.0

Experiment I V.—Conditions favourable to ripening. Variety B.H. 10(12).

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Average gain per cent.	Amount tons per acre.	Average gain per cent.	Yield tons per acre.	Average gain per cent.
Nil	15.73	—	21.77	—	3.42	—
½ L.R.	15.60		23.14		3.61	
L.R.	15.69 } 15.68	Nil	22.22 } 22.95	5.2	3.49 } 3.60	5.2
1½ L.R.	15.75		23.50		3.70	

Experiment X I V.—Conditions unfavourable to ripening. Variety B.H. 10(12).

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Gain per cent.	Amount tons per acre.	Gain per cent.	Yield tons per acre.	Gain per cent.
Nil	10.69	—	59.45	—	6.36	—
½ L.R.	10.10	−5.5	62.87	+5.75	6.35	Nil

Conditions Very Favourable to Ripening.
B. 156, plant canes, 20 months old.

Available 96° sugar per cent. cane.

The plant canes on the unlimed plots contained on the average 11.64 per cent. of available 96° sugar. The percentage rises to 11.85 on the plots limed to half the requirement of the soil. At the full lime requirement it falls to 11.67 per cent., a value approximately equal to that for the unlimed plots. At one-and-a-half the lime requirement there is a fall to 11.42 per cent., a value lower than that for the unlimed plots.

The rise and subsequent fall in available sugar per cent. cane obtains both for the plant canes on the unpenmanured and on the penmanured plots of the experimental area. The observed values for the two series of plots are set out in Table XIV.

TABLE XIV.—*Effect of size of dressing of limestone on amount of available 96° sugar per cent. cane, in the presence and absence of pen manure, under conditions very favourable to ripening. Variety B. 156.*

Dressing of limestone.	Available 96° sugar per cent. cane.	
	Unpenmanured plots.	Penmanured plots.
Nil	11.68	11.58
½ L.R.	12.05	11.68
L.R.	11.84	11.39
1½ L.R.	11.55	11.29

The average percentage of available 96° sugar in cane on the plots without pen manure is 11.78. The value for the plots with pen manure is 11.48. The depression due to the dressing of pen manure is statistically significant.

By fitting an equation of the type $Y = A + B\xi_1 + C\xi_2$ the rise and fall in available 96° sugar per cent. cane can be shown to be statistically significant on both unpenmanured and penmanured plots. On the unpenmanured plots maximum available percentage of sugar occurs at 0.66 the lime requirement of the soil of the experimental area. On the penmanured plots the maximum occurs at 0.17 the lime requirement. The difference between the two maxima is statistically significant, P being less than 0.01. *It would seem, therefore, that the dressing of lime associated with the maximum percentage of available 96° sugar in cane is dependent on the basal manurial treatment and can be significantly smaller in the presence than in the absence of pen manure.*

It will be recollected that a similar rise and fall was found to obtain in percentage sucrose in cane as the dressing of lime increased, the maximum values for sucrose lying at 0.67 and 0.39 the lime requirement on the unpenmanured and penmanured plots, respectively. As size of dressing of lime had no well-defined effect on the coefficient of purity under the conditions of this experiment, a parallel rise and fall in percentage available 96° sugar is to be expected. The curves obtained when available 96° sugar is plotted against size of dressing of lime very closely resemble the sucrose-limestone curves recorded in Figure I.

The maximum point on the available 96° sugar-limestone curve for all plots (whether penmanured or not) lies at 0.57 the lime requirement of the soil of the experimental area, a value identical with that for the maximum point on the corresponding sucrose-limestone curve.

Yield of cane to the acre.

A curve of diminishing returns is obtained when yield of plant canes is plotted against size of dressing of limestone. The unlimed plots gave a yield of 30.73 tons of cane to the acre. The limed plots gave yields of 33.19 tons, 32.17 tons and 33.23 tons, in order of increasing size of dressing. The average gain resulting from liming of 2.13 tons cane to the acre, or 6.9 per cent., might be due to chance less than once in 20 times.

Yield of commercial 96° sugar to the acre.

The relationship between yield of commercial 96° sugar and size of dressing of limestone under the conditions of the experiment is graphically represented in Figure VII. *As the dressing of limestone increases there is a rise and fall in yield of sugar similar to that found for percentage of sucrose and of available sugar in cane. It follows that the general form of the curve for yield of sugar to the acre is determined primarily by the effect of manurial treatment with limestone on the quality of the crop rather than by its effect on yield of cane, under the conditions very favourable to ripening.*

The effect of liming on yield of cane, however, has the two following important secondary influences on the shape of the curve for yield of sugar :—

(i) The maximum point on the curve for commercial sugar lies at 0.87 the lime requirement of the experimental area, a value which can be shown to be significantly larger than that for the maximum point on the curves for sucrose and available sugar (0.57 the lime requirement). The shift in position of the maximum point is due to the gain in yield of cane resulting from liming.

In this experiment a dressing of limestone equal to half the lime requirement of the soil was found adequate for maximum yield of cane. If yield of cane had increased continuously up to the full lime requirement, as in the case of the majority of liming experiments laid down in Trinidad (13), the dressing of limestone associated with maximum yield of sugar to the acre would have been still larger.

(ii) Although the concentration of sucrose and available sugar is smaller on the plots limed to one-and-a-half the lime requirement than on the unlimed plots, yield of commercial sugar to

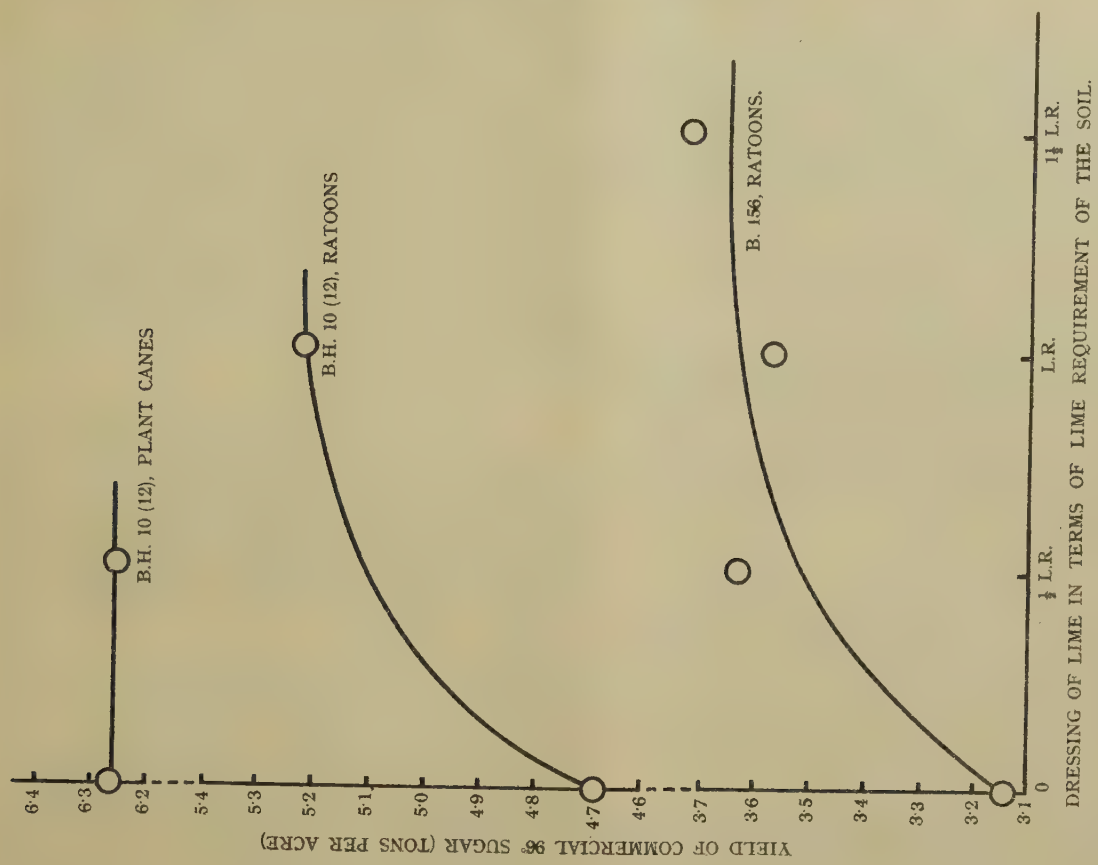


FIG. VIII.—EFFECT OF INCREASING MANURIAL TREATMENT WITH GROUND LIMESTONE ON YIELD OF COMMERCIAL 96° SUGAR UNDER MOISTURE CONDITIONS UNFAVOURABLE TO RIPENING.

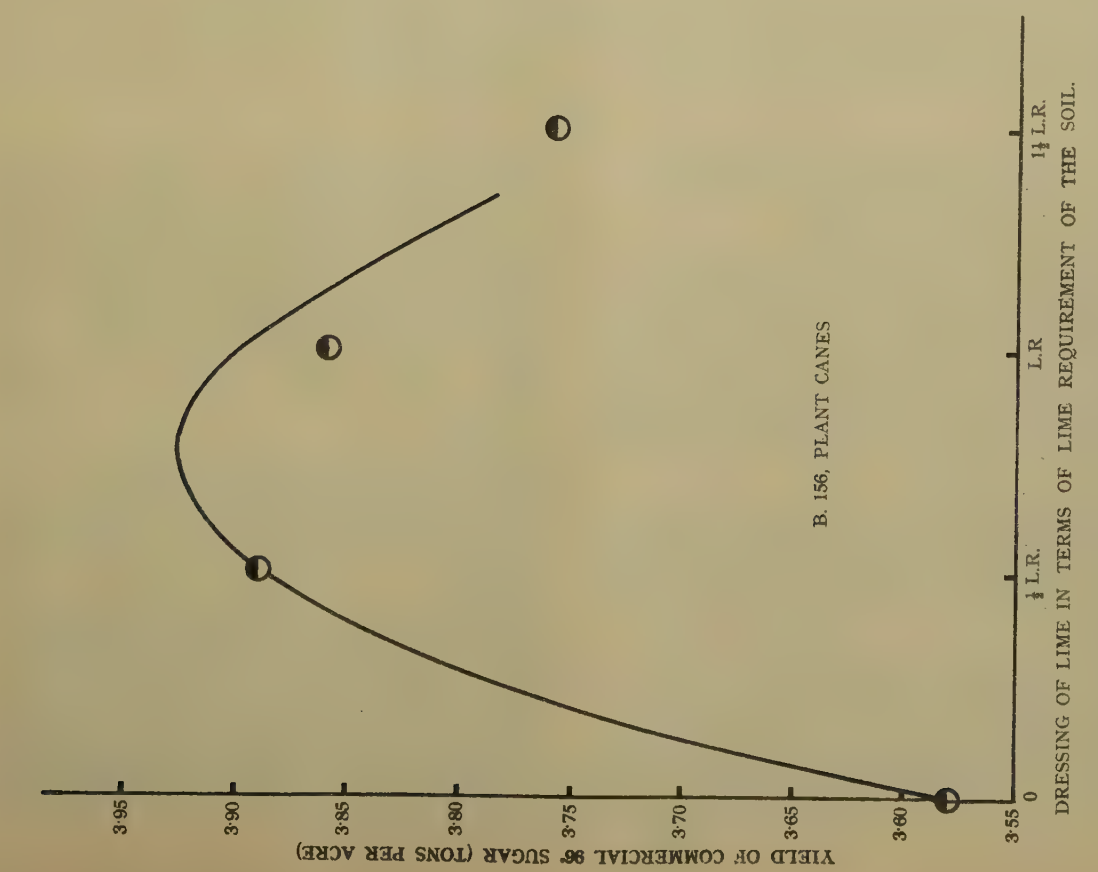


FIG. VII.—EFFECT OF INCREASING MANURIAL TREATMENT WITH GROUND LIMESTONE ON YIELD OF COMMERCIAL 96° SUGAR UNDER MOISTURE CONDITIONS VERY FAVOURABLE TO RIPENING.

the acre is greater on the overlimed than the unlimed plots, the fall in crop quality being in part counterbalanced by the gain in yield of cane.

In certain circumstances (3, 13) dressings in excess of the lime requirement can lead to loss in yield of cane. Should such a loss accompany a fall in crop quality the drop in yield of commercial sugar due to overliming would be very large.

Conditions Favourable to Ripening.
B.H. 10(12), *plant canes,* 18 *months old.*

Available 96° *sugar per cent. cane.*

Manurial treatment with limestone had no effect on the content of sucrose or the purity of juice of the plant canes. Consequently liming caused no change in the percentage of available 96° sugar in cane. The average values for the unlimed and limed plots are 15.73 per cent. and 15.68 per cent., respectively.

Yield of cane to the acre.

A curve of diminishing returns is obtained when yield of plant canes is plotted against size of dressing of limestone. The unlimed plots gave a yield of 21.77 tons of cane to the acre. The limed plots gave an average yield of 22.95 tons. The average gain of 5.2 per cent. resulting from liming might be due to chance less than once in 20 times.

Yield of commercial 96° *sugar to the acre.*

Under the conditions favourable to ripening the curve for yield of commercial 96° *sugar to the acre is identical in form with the curve for yield of cane, for manurial treatment with limestone had no appreciable effect on crop quality.* The unlimed plots gave 3.42 tons of sugar to the acre, and the limed plots 3.60 tons, a significant gain of 5.2 per cent.

Conditions Unfavourable to Ripening.
B.H. 10(12), *plant canes,* 17½ *months old.*

Available 96° *sugar per cent. cane.*

The dressing of one-half the lime requirement of the soil led to a depression in the sucrose content and the purity of the juice of the plant canes. Consequently the amount of available sugar per cent. cane is smaller for the limed plots (10.10 per cent.) than for the unlimed plots (10.69 per cent.). The difference is statistically significant. The proportionate loss in concentration of available sugar is 5.5 per cent.

Yield of cane to the acre.

The unlimed plots gave a yield of 59.45 tons of plant canes to the acre. The limed plots gave a yield of 62.87 tons. The gain of 3.42 tons of cane to the acre (or 5.7 per cent.) is statistically significant.

Yield of commercial 96° *sugar to the acre.*

In this particular case no gain in yield of commercial sugar resulted from liming, for the increase in tonnage of the plant cane is counterbalanced by the depression in concentration of available sugar. *Under conditions unfavourable to ripening, therefore, no immediate gain in yield of commercial sugar may accrue from liming, even though there is an increase in yield of plant canes.*

To place this conclusion in its true perspective it should be noted that in this experiment alone, of the many experiments of the kind laid down in Trinidad, has no immediate gain in yield of commercial sugar resulted from liming to one-half the lime requirement of the soil. Further, it is necessary to take account of the residual effects of manurial treatment with limestone on yield of commercial sugar to obtain a full measure of the value of the operation.

Ratoon Canes.

Conditions Unfavourable to Ripening.

Data for ratoon canes of Experiments V, IV and XV, relating to the residual effects of size of dressing of ground limestone on yield of cane and on available and commercial 96° sugar under moisture conditions unfavourable to ripening, are set out in Table XV.

Available 96° *sugar per cent. cane.*

Manurial treatment with limestone led to a depression in the amount of available 96° sugar per cent. cane in all three experiments on ratoon canes. The average values for the depression are 0.50 sugar per cent. cane (Experiment V), 0.32 sugar per cent. cane (Experiment IV) and 0.78 sugar per cent. cane (Experiment XV). The corresponding proportionate losses are 4.0 per cent., 2.1 per cent. and 6.0 per cent., respectively. They are of the same order as the proportionate loss recorded for the experiment on plant canes sampled under conditions unfavourable to ripening (Experiment XIV).

Yield of cane to the acre.

Average residual gains in yield of cane to the acre amounting to 5.27 tons (Experiment V) 1.84 tons (Experiment IV) and 6.57 tons (Experiment XV) resulted from liming. The equivalent proportionate gains are 20.8 per cent., 8.3 per cent. and 18.3 per cent., respectively. Gains of this magnitude are characteristic of the earlier residual effects of ground limestone on yield of cane although still larger gains are sometimes obtained (12).

Yield of commercial 96° *sugar to the acre.*

In all three experiments the gain in yield of cane far more than counterbalances the depression in concentration of available sugar in cane. The average gain to the acre of commercial 96° sugar amounted to 0.50 tons in Experiment V, 0.20 tons in Experiment IV and 0.53 tons in Experiment XV. *The case of Experiment XV is worthy of special mention for although manurial treatment with limestone led to a depression of* 0.72 *lb. sucrose per* 100 *lbs. of juice and of* 2.6 *units in the coefficient of purity (the largest depressions so far recorded in liming experiments laid down in Trinidad), the gain in yield of sugar exceeds half a ton to the acre.*

TABLE XV.—*Effect of size of dressing of limestone on yield of 96° sugar under conditions unfavourable to ripening. First ratoon-canes.*

Experiment V.— Variety B. 156.

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Average gain per cent.	Amount tons per acre.	Average gain per cent.	Yield tons per acre.	Average gain per cent.
Nil	12.36	—	25.39	—	3.14	—
½ L.R.	11.77		30.82		3.63	
L.R.	11.91 } 11.86	−4.0	29.86 } 30.66	+20.8	3.56 } 3.64	+15.9
1½ L.R.	11.89		31.29		3.72	

Experiment I V.— Variety B.H. 10(12).

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Average gain per cent.	Amount tons per acre.	Average gain per cent.	Yield tons per acre.	Gain per cent.
Nil	15.02	—	22.30	—	3.35	—
½ L.R.	14.59		23.36		3.41	1.8
L.R.	14.84 } 14.70	−2.1	23.68 } 24.14	+8.3	3.51 } 3.55	4.8 } 5.9
1½ L.R.	14.66		25.38		3.72	11.0

Experiment X V.— Variety B. H. 10(12).

Dressing of limestone.	Available 96° sugar.		Yield of cane.		Commercial 96° sugar.	
	Amount per cent. cane.	Gain per cent.	Amount tons per acre.	Gain per cent.	Yield tons per acre.	Gain per cent.
Nil	13.06	—	35.93	—	4.69	—
L.R.	12.28	−6.0	42.50	+18.3	5.22	+11.3

The effect of size of dressing of limestone (within the range one-half to one-and-a-half the lime requirement) on yield of sugar appears unimportant in Experiment V. In Experiment IV, however, there is a well-defined increase in the yield as the dressing increases to its maximum value.

The relationship between yield of commercial 96° sugar and size of dressing of limestone, under conditions unfavourable to ripening, is graphically represented in Figure VIII for the plant canes of Experiment XIV and the ratoon canes of Experiments V and XV.

Optimum Dressing of Lime in Relation to Yield of Commercial 96° Sugar.

The data recorded in Tables XIII and XV provide information in relation to size of dressing of ground limestone for optimum gain in yield of commercial sugar.

Plant Canes.

In the experiment sampled under conditions very favourable to ripening, yield of commercial sugar increases rapidly until the dressing of limestone is equal to half the lime requirement of the experimental area. At dressings greater than this yield of sugar continues to increase, but at a much diminished rate, until 0.87 the lime requirement is attained. A fall in yield of sugar begins to set in from that point.

In the experiment sampled under conditions favourable to ripening, yield of sugar again increases rapidly up to half the lime requirement. At heavier dressings of limestone the yield remains appreciably unchanged.

In the experiment sampled under conditions unfavourable to ripening a dressing equal to half the lime requirement led to no gain in yield of sugar. The results of this experiment are believed to be abnormal.

Ratoon Canes.

All the experiments on ratoon canes were sampled under conditions unfavourable to ripening. In one, yield of sugar increased rapidly up to half the lime requirement, heavier dressings giving little additional benefit. In another, yield of sugar increased continuously up to the maximum dressing of one-and-a-half the lime requirement. In a third, a dressing equal to half the lime requirement led to a very satisfactory gain in yield.

Discussion and Conclusions.

The recorded data provide measures of the immediate or residual effect of dressings of ground limestone on the yield of sugar obtained from one crop of cane, not from a succession of crops. It has been shown that the beneficial effects of a single dressing of limestone on yield of cane can persist over a number of crops (3, 12). There is in general no reason why the continued beneficial effects of a single dressing of limestone on yield of cane should not be accompanied by a parallel series of effects on yield of sugar.

The trend of the data set out in this paper suggest that a dressing of limestone equal to half the lime requirement of the soil can be relied on to give satisfactory gains in yield of sugar. Even if in exceptional cases this dressing has no immediate effect on the yield of sugar given by the first crop of plant canes, definite and paying residual gains should be obtained from the crops which follow.

Under the conditions which obtain in Trinidad the gains in yield of cane, which result from liming, as a rule increase continuously until the dressing is as large as the lime requirement of the soil, although the rate of gain greatly diminishes when the dressing exceeds half the lime requirement. As moisture conditions are rarely very favourable to ripening in Trinidad, and as the adverse effect of liming on the percentage of available 96° sugar in cane appears to be appreciably unaffected by the size of dressing within the limits one-half to one-and-a-half the lime requirement when moisture conditions are unfavourable to ripening, it is probable that dressings as large as the lime requirement may in general be applied without disadvantage.

Dressings in excess of the lime requirement appear definitely inadvisable, for they rarely give rise to additional gain in yield of cane and they can cause a depression in concentration of available sugar in cane should moisture conditions become very favourable to ripening.

Summary.

The effects on increasing manurial treatment with ground limestone on the amount of available 96° sugar per cent. cane and on yield of commercial 96° sugar to the acre are summarised in Table XVI.

Effect of Size of Dressing of Limestone on Available 96° Sugar per cent. Cane.

Under the conditions very favourable to ripening, amount of available 96° sugar per cent. cane was found at first to rise to a maximum and then significantly to fall as the dressing of ground limestone increased. The position of the maximum, in terms of the lime requirement of the soil, appears to depend on the basal manurial treatment.

Under the conditions favourable to ripening, no change in concentration of available sugar in cane was found to result from liming, within the limits of the size of dressing investigated.

Under conditions unfavourable to ripening, liming was found to depress the concentration of available sugar in cane in four independent experiments.

Effect of Size of Dressing of Limestone on Yield of Commercial 96° Sugar.

Under the conditions very favourable to ripening, the effect of size of dressing of limestone on yield of commercial 96° sugar was found to be determined primarily by the effect of the dressing on crop quality rather than on yield of cane. As in the case of concentration of available sugar in cane, the curve for yield of sugar rises to a maximum and then significantly falls, with increasing dressings of lime. The position of the maximum point on the curve and the magnitude of the adverse effect of overliming, however, are dependent on the gain in yield of cane which results from liming.

TABLE XVI.—*Summary of effects of increasing dressings of limestone on available sugar in cane and on yield of cane and of sugar to the acre.*

EFFECTS WHICH CAN BE ESTABLISHED AS STATISTICALLY SIGNIFICANT ARE PRINTED IN ITALICS.

Experiment.	Variety of cane.	Stage in crop series.	Available 96° sugar per cent. cane.	Yield of cane tons per acre.	Yield of commercial 96° sugar tons per acre.	Conditions for ripening.
V	B. 156	Plants	*Rise and fall*	*Rise*	*Rise and fall*	Very favourable
IV	B.H. 10(12)	Plants	Nil	*Rise*	*Rise*	Favourable
XIV	B.H. 10(12)	Plants	*Depression*	*Rise*	Nil	Unfavourable
V	B. 156	1st R.	Depression	*Rise*	*Rise*	Unfavourable
IV	B.H. 10(12)	1st R.	Depression	*Rise*	Rise	Unfavourable
XV	B.H. 10(12)	1st R.	Depression	*Rise*	*Rise*	Unfavourable

Under the conditions favourable to ripening, gain in yield of sugar was found to be controlled by the effect of size of dressing of lime on yield of cane, the concentration of available sugar in cane being unaffected by liming.

Under conditions unfavourable to ripening, gain in yield of sugar was found in general to be dependent primarily on the effect of liming on yield of cane rather than on crop quality, for in three experiments out of four the adverse effects of manurial treatment with limestone on the concentration of available sugar in cane were not important in comparison with its beneficial effects on yield of cane. In the fourth experiment, the results of which are believed to be abnormal, the *immediate* gain in yield of cane was counter-balanced by the depression in concentration of available sugar.

Optimum Dressing of Lime in Relation to Yield of Commercial 96° *Sugar.*

Under the conditions which obtain in Trinidad it would appear that a dressing of ground limestone equal to half the lime requirement of the soil can be relied on to give satisfactory gain in yield of sugar. It is probable that a dressing as large as the lime requirement may in general be applied without disadvantage, but a dressing in excess of the lime requirement appears definitely inadvisable.

The effects of manurial treatment with lime on the concentration of sucrose in cane and in juice, on the concentration of dissolved solids in juice and on the purity of juice have been summarised earlier in this paper.

References.

(1) Noel Deerr (1921).—*Cane sugar*, p. 68. *Norman Rodger*, London.

(2) Williams, C. H. B. and Follett-Smith, R. R. (1931-36). Field experiments with sugar cane. *Sugar Bulletins Nos. I-V. Department of Agriculture, British Guiana.*

(3) Turner, P. E. (1935).—Recent investigations on sugar-cane and sugar-cane soils in Trinidad, I and II. *Tropical Agriculture*, XII, 10, p. 262 ; 11, p. 293 ; 12, p. 320.

(4) Turner, P. E. (1930).—The state of unsaturation of the soil in relation to its field behaviour and lime requirement. *Soil Science*, XXX, p. 349.

(5) Davies, J. G. (1930).—The sampling of cane in the field. *Memoir No. 3, Sugar Technology Series. Imperial College of Tropical Agriculture, Trinidad.*

(6) Methods of chemical control for cane sugar factories (Revised 1931). *Association of Hawaiian Sugar Technologists.*

(7) Fisher, R. A. (1932).—*Statistical methods for research workers. Oliver and Boyd.* Edinburgh and London.

(8) Rodriguez, G. (1934).—The effects of soil liming on the composition of sugar cane. *Proceedings of the Sugar Cane Investigation Committee of Trinidad*, IV, 6, p. 389.

(9) Pritchett, G. H. (1924).—Crushed limestone shell *v.* no fertiliser. *Sugar News*, V, p. 186.

(10) Prinsen Geerligs (1924). *Cane sugar and its manufacture*, p. 87. Norman Rodger, London.

(11) Davies, J. G. (1935). A simple explanation of the technological terms used to express the results of sugar-cane experiments. *Tropical Agriculture*, XII, 12, p. 333.

(12) Turner, P. E. (1936).—Field experiments on sugar cane in Trinidad. Annual reports for 1936, p. 5. *Sugar Cane Investigation Committee of Trinidad.*

(13) Turner, P. E. (1934).—Studies on sugar cane and sugar-cane soils, I. *Empire Journal of Experimental Agriculture*, II, 5, p. 78.

CITRUS SCAB ON MARSH GRAPEFRUIT.

Citrus scab, caused by *Sphaceloma fawcetti* Jenkins (*Sporotrichum citri* Doidge and Butler), occurs commonly on the sour orange in Trinidad. In many districts it is considered a serious disease of young nursery stock where sour orange seedlings are being raised for budding. Hitherto this disease has only been met with in isolated instances on the grapefruit in Trinidad, though it is well known on this host in Florida, West Africa, and other countries. It causes considerable damage both to the foliage and to the fruit rendering the latter unfit for market. In January, 1937, the disease was found on between two and three hundred three years old Marsh grapefruit trees in the Northern Range area of Trinidad. Both leaves and fruit were found to be affected, but the latter only slightly. From the age of the attacked leaves it was deduced that the disease had first appeared in October or November, 1936. Careful comparisons of both macroscopic and microscopic appearance of the fungus on the sour orange and the Marsh grapefruit were made, and they were found to be morphologically identical. Measurements of the spores of the fungus on both were 13μ (8μ-18μ) in length and 4μ (2.5μ-5μ) in breadth. These measurements agree with those of *Sphaceloma fawcetti scabiosa* given by Jenkins (1936) as 10-$17\mu \times 2.5$-5μ. This will have to be confirmed by means of inoculation experiments.

Scab is considered to be one of the more serious fruit diseases of grapefruit in other countries since its lesions render a large quantity of fruit unsightly and unfit for marketing. The present outbreak in Trinidad occurred at the end of a long and very wet rainy season and is probably directly to be attributed to the abnormal weather conditions which have prevailed. It is possible that with the onset of the dry season further spread of the disease will be impossible and that when the diseased material at present on the trees has been cleared away and destroyed the disease will not occur again in this manner. The diseased area will be kept under observation, since in the unlikely event of its spreading, more drastic control measures may be required.

R. E. D. Baker.

TROPICAL FRUITS AND VEGETABLES. AN ACCOUNT OF THEIR STORAGE AND TRANSPORT.

By C. W. Wardlaw.
(*Low Temperature Research Station*).

Introduction.

In this publication an attempt has been made to bring together an account of the storage and transport of a number of fruits and vegetables indigenous to, or capable of being grown in, the tropics. The successful cold storage of each commodity depends on a number of factors, including the variety, environmental conditions of growth, the maturity at which it is harvested, the rapidity and care with which it is removed to cold storage, the actual temperature, humidity and duration of storage, and the time required for distribution on removal from storage. Where available, information on these several topics has been included.

With rare exceptions tropical fruits are notoriously subject to wastage. Great care in handling and, almost invariably, the use of refrigeration are necessary before uniform supplies of attractive fruit can be made available on temperate markets.

Much of the literature on tropical fruit and vegetable storage is fragmentary and inconclusive, partly because the science of food preservation as a whole is yet in its infancy, partly because pre-storage factors exercise a profound influence on the subsequent storage life. Thus, a storage temperature found to be optimal for a particular fruit in one country may be quite unsuitable for the same fruit grown elsewhere. The investigator of such problems is, accordingly, brought into sharp contact with the many physiological problems pertaining to the development, ripening and senescence of fruits, and in particular with the effect of low temperatures on the processes of metabolism. In this paper, attention will be restricted to the major practical issues.

A surprising number of vegetables, usually regarded as temperate or warm temperate in habitat, have now been grown with a fair measure of success in the tropics. As progress is made in the breeding, selection and acclimatisation of new varieties, the production of such vegetables in the tropics will increase, if not for export at least for local consumption. The value of the short but highly productive cropping period, characteristic of tropical conditions, can be greatly increased where refrigeration facilities are available to extend the consumption period. So far the relevant storage literature is scanty, and, of necessity, many of the storage temperatures cited refer to produce obtained under temperate conditions. While such data may be used as a guide in arranging local storage trials, it will generally be found that tropical produce requires higher storage temperatures in order that chilling may be avoided.

The uses to which refrigeration may be put in the handling of tropical produce are many and various. Cold storage may be resorted to in order to avoid glut periods locally or unfavourable marketing periods abroad. Where intended for export, fruit may be harvested relatively immature, transported at a suitably low temperature (which retards but does not entirely arrest maturation processes) and subsequently ripened at a higher temperature. On the other hand, the fruit may be harvested when it is practically " eating-ripe ", and held at a low temperature until required for immediate consumption. As a rule, rapid cooling after harvesting is desirable. In some instances the practice of pre-cooling fruit is adopted: by this term is inferred the rapid cooling of fruit to the required transport temperature prior to its being stowed in the refrigerator car or refrigerated hold; this procedure has the advantage of giving uniformity of temperature to bulk consignments, and cooling at rates generally in excess of that possible on shipboard.

The prime factor in the overseas transport of perishable tropical produce is, of course, the refrigerated ship. The absence of suitable shipping has been and still is the chief obstacle to the wider utilisation of tropical produce. The type of cold-storage installation is important. As the tissues of stored fruits and vegetables are still alive, they require environmental conditions which will permit of approximately normal, though retarded, maturation so that the appearance, flavour, texture, aroma and other qualities for which they are prized, will be preserved. In general, the equipment and design of refrigerated holds should be such as to permit of rapid cooling, the maintenance of the steady temperature, relative humidity, and, if necessary, gas concentrations optimal for the fruit in question. In particular, carriage at too low a temperature, resulting in various types of chilling, which may be manifest during storage or subsequent distribution, should be avoided. Where, as in the older type of refrigerated ship, the holds are cooled by wall-grids, the resulting lack of uniformity in temperature involves considerable danger of chilling in the fruit in proximity to the grids and fungal wastage in the fruit remote from the grids where temperatures are high. In modern fruit ships this system is no longer used, refrigeration being supplied in the form of circulating air cooled to the required temperature by passing over cold pipes (the battery or air-blast system). The circulating air, which in time becomes vitiated by the carbon dioxide of respiration and by volatile substances given off by the fruit—which may accelerate ripening—is periodically discharged and a fresh supply taken into circulation.

The part which refrigeration can play in local food economics in the tropics should not be overlooked. Every year sees an increase in the extent to which it is being applied in the preservation of perishable produce. Its rational use cannot fail to be profoundly beneficial not only in handling produce intended for export but also in the conservation of locally produced foodstuffs.

Artichokes.

Two distinct and botanically unrelated kinds of artichoke are known: the true artichoke, known as the globe or French artichoke (*Cynara scolymus—C. cardunculus*) is a thistle-like plant, native to the Mediterranean region, the edible portion being the unopened flower buds. The Jerusalem artichoke or girasole (*Helianthus tuberosus*), which is neither an artichoke nor native to Palestine—it is of N. American origin—is grown almost exclusively for the edible underground tubers (1).

The Globe Artichoke.

The heads are cut when they have attained their greatest size prior to the appearance of the floral parts (7).

According to Rasmusson (4) the life of artichokes can be prolonged by cold storage at 32° to 33.5°F. for an additional period of four months over ordinary storage.

The Jerusalem Artichoke.

The Jerusalem artichoke or girasole has long been in general use in many European countries. In the United States of America, on the other hand, the plant, though widely known, is little used, and only recently has been given serious attention as a source of raw material for the commercial production of fructose (laevulose) and alcohol (5). Though the plant is best adapted to temperate regions, it can also be grown with some measure of success in the tropics (2, 3).

As the tuber periderm is thin and easily ruptured, a rapid loss of moisture takes place when tubers are exposed to room temperatures; wastage due to micro-organisms may also be considerable. The best method of storage, in temperate countries, consists in leaving tubers in the ground and digging them as required. Among earlier references Rasmusson (4) states that tubers in cold storage at 32° to 33.5°F. kept for four months longer than in ordinary storage. Traub *et al.* (6), in storage trials, observed that artichoke tubers may be successfully stored either as a truck crop or as propagating stock at 32° to 35°F. and relative humidity of 89 to 92 per cent. Under these conditions, tubers were found to have a larger amount of water-soluble carbohydrate per unit green weight than tubers left in the ground over winter. At temperatures above 40°F., stored tubers lose moisture rapidly, shrivel, and are so subject to diseases that the entire consignment may sometimes be lost.

Trinidad-grown tubers, subjected to air-blast refrigeration at 45°F., showed marked symptoms of desiccation (perhaps accompanied by some chill injury). In still air at 60°F. tubers kept in good condition for two to three weeks but thereafter became mouldy.

References.

1. Experiment Station Work.—IV. Jerusalem Artichokes. *Farmers' Bul.* 73, *U.S. Dept. Agr.*, Washington, 1908.
2. Freeman, W. G. and Williams, R. O.—Our Local Foods, Their Production and Use. *Dept. Agr. Trinidad and Tobago*, 1918.
3. Macmillan, H. F.—Tropical Gardening and Planting. *H. W. Cave & Co.*, Colombo, 1925.
4. Rasmusson, L.—Preservation of Vegetables in Cold Storage. *Month. Bul. Inf. Refrig. Rept. 5th Int. Congr. Refrig. Rome*, 1928, p. 48.
5. Shoemaker, D. N.—The Jerusalem Artichoke as a Crop Plant. *U.S. Dept. Agr. Tech. Bul.* 33, 1927.
6. Traub, H. P., Thor, C. J., Willaman, J. J. and Oliver, R.—Storage of Truck Crops.—The Girasole, Helianthus tuberosus. *Plant Physiol.*, IV. 1. 1929.
7. Wellington, J. W.—Culture of the Globe Artichoke. *New York Agr. Exp. Sta. Bul.* 435, 1917.

Asparagus.

All the common varieties of this vegetable have been derived from one species, *Asparagus officinalis*, the genus being native to the Old World. Very full accounts are now available of the methods of planting, cultivating, harvesting and preparing for market (7, 8, 9, 16, 17).

Large, well-developed crowns or rootstocks are essential to the production of good asparagus. The spears or shoots are cut once or twice per day, according to the rate of growth. If white asparagus is desired the shoots must be cut just as they force their way through the surface of the soil as they quickly become green on exposure to light. In Europe nearly all of the asparagus sold in the fresh condition is white, but in the United States of America, it may be marketed with the spears entirely blanched, almost entirely blanched, with a green tip, or green throughout except for the butts (9). The green product is now becoming increasingly popular (9).

During the progress of the cutting season there is an increase in the sugar content of the shoots and a decrease in the protein and lignin (11). Photosynthesis carried on by the shoot itself is thought to be a factor in the recorded sugar increase.

Storage of Propagating Crowns.

Propagating crowns, when hauled from the field, should be placed on a dry floor or on well drained ground. The best storage temperature is about 40°F. (9) but, provided the atmosphere is dry and air circulation among the crowns adequate, storage for long periods at higher

temperatures is also feasible. If the crowns become moist either from external dampness or from "sweating" in the heaps, they soon decay. Excessive desiccation of the crowns should be avoided.

Packing.

Fresh asparagus may be packed loose in the crate or bunched and crated, the latter procedure being the more usual. In the large producing areas in California, well equipped packing houses are provided for the several operations of grading, bunching and wrapping (9, 16, 17).

Tests in Georgia (2) with asparagus wrapped with films of moisture-proof cellulose have shown that the loss in weight during storage is materially reduced and the storage life at ordinary temperatures prolonged. Recent work in Germany (1) indicates the value of cellophane wrappers in the conservation of asparagus.

Quality Changes after Harvesting.

Defects developing after harvesting include excessive wilting, elongation of the spears and opening up of the heads, rotting due to fungal and bacterial pathogens, and general deterioration in quality. Bisson, Jones and Robbins (3) have analysed the several factors involved, standardised samples being stored at 33°, 41°, 56°, 77° and 95°F., and examined microscopically and chemically at intervals of 24 hours. Their results show that green asparagus should be bunched, packed and placed under refrigeration—just above 32°F.—as soon after harvesting as possible, since certain changes in structure and chemical composition, which affect the edible quality, take place with great rapidity.

Asparagus spears grow in length and increase in weight in the crate if the butts are resting on moist moss. The growth rate is least at 33°F. but increases with temperature. The greatest increase in length takes place during the first 24 hours after cutting, hence the necessity for rapid cooling. During storage at higher temperatures, 75° to 95°F., mould appears on the spears within a few days. A loss in reducing substances and in total sugars takes place at all temperatures, especially from 56° to 95°F., the maximum rate of loss occurring during the first 24 hours.

At all storage temperatures there is a definite increase in the amount of fibrous material. This could be demonstrated microscopically and also by estimating the amount of crude fibre present. The increase in fibrous material takes place most rapidly immediately after harvesting. Its formation is accelerated at the higher and to some extent arrested at the lower temperatures. The initial toughness of the spears may therefore be accentuated by unfavourable storage conditions.

Precooling and Cold Storage.

It has been seen that asparagus loses much of its food value, and therefore its saleability, within a few hours after cutting unless it is placed in storage at a relatively low temperature. According to Platenius, Jamison and Thompson (13) no other vegetable deteriorates so rapidly as asparagus at ordinary temperatures. If the bunches are stood on damp packing and stored at 32°F. immediately after cutting, this commodity should keep in good condition three to four weeks (15). If received at the storage plant after a long haul from a distant point of production it cannot be expected to keep longer than three to six days (14).

In California the larger consignments, at the height of the season, are precooled before being loaded into refrigerated cars, the cars being re-iced as required during the transport period (9). According to Hanna (8) it usually takes from 8 to 12 hours to bring the temperature down to 40°F. All-green asparagus, which has a higher respiration rate than spears with white butts, takes longer to cool. Temperatures of 33°F. and R.H. of 90 per cent. (5), 32° to 35.5° F. and R.H. of 80 per cent. (4, 5, 12) are cited as being suitable for asparagus storage over periods of 21 to 50 days. Platenius *et al.* (13) quote a storage temperature of 32°F. and R.H. of 95 to 98 per cent. as affording a maximum storage period of one week. The use of ozone in asparagus storage has been considered by Kochs (10) in Germany; in these experiments the duration of storage at various low temperatures could not be prolonged beyond two to three weeks.

Gas Storage.

In gas storage experiments, Brooks *et al.* (3A) found that asparagus exposed to early treatment with carbon dioxide (*i.e.* during cooling) showed improved appearance, keeping quality and flavour over untreated control lots. "Asparagus exposed to 25 to 30 per cent. of carbon dioxide at temperatures of 60° to 70°F. for 18 to 24 hours had a better flavour than asparagus held at the same temperature without carbon dioxide and as good as or better flavour than asparagus held at 32° or 40°F. for the same period. Asparagus that was exposed to 25 to 30 per cent. of carbon dioxide for 48 hours or to 40 per cent. or more of carbon dioxide for 24 hours was sometimes found to have an objectionable flavour." Thornton (18) has reported a browning of the outer bud scales and the development of water-soaked areas on asparagus exposed to 50 to 80 per cent. of carbon dioxide for 3 days. Early treatment with carbon dioxide was also effective in controlling fungal rotting.

References.

1. Anon.—Asparagus Storage. *Ice & Refrig.*, XCI, 5, p. 393, 1936.
2. Anon.—Asparagus Packed for Profit. *Market Growers' Jour.*, 52, 1933.
3. Bisson, C. S., Jones, H. A. and Robbins, W. W.—Factors Influencing the Quality of Fresh Asparagus after it is Harvested. *Univ. Calif. Agr. Exp. Sta. Bul.* 410, 1926.

3A. Brooks, C., Bratley, C. O. and McColloch, L. P.—Transit and Storage Diseases of Fruits and Vegetables as Affected by Initial Carbon Dioxide Treatments. *U.S. Dept. Agr. Tech. Bul.* 519, 1936.

4. Cold Storage Temperatures. *Month. Bul. Inf. Refrig.* III, p. 407, 1922.
5. Friebe Scupin, L.—Eis und Kaelt. Ind., Jan., 1933.—Abstract in *Int. Bul. Inf. Refrig.*, XIV, p. 338, 1933.
6. Gottsch, G.—The Frigorific Machines and their Instalment: Favourable Conditions for Refrigerated Goods. Abstract in *Month. Bul. Inf. Refrig.*, Vol. I, p. 27, 1920.
7. Hardy, R. B.—Asparagus Culture. *U.S. Dept. Agr. Farmers' Bul.* 61, 1897.
8. Hanna, G. C.—Asparagus Production in California. *Calif. Agr. Exten. Serv. Circ.* 91, 1935.
9. Jones, H. A. and Robbins, W. W.—The Asparagus Industry in California. *Calif. Agr. Exp. Sta. Bul.* 446, 1928.
10. Kochs, D.—Results obtained in the Cold Storage of Fruits and Vegetables. Z. f. Eis. und Kaelt-Ind. Aug., 1933. *Int. Bul. Inf. Refrig.* 14 p. 1182, 1933.
11. Morse, F. W.—Some Effects of Fertilisers on the Growth and Composition of Asparagus Roots. *Massachusetts Agr. Exp. Sta. Ann. Rept.* 25, 156, 1913.
12. Plank, R.—Versuche uber de Kaltlagerung von Obst und Gemuse. *Z. f.d. ges. Kaelt-Ind. Berlin*, 1927.
13. Platenius, H., Jamison, F. S. and Thompson H. C.—Studies on Cold Storage of Vegetables. *Cornell Univ. Agr. Exp. Sta. Bul.* 602, 1934.
14. Refrigerating Data Book. *Publ. Amer. Soc. Refrig. Eng.*, 3rd Edition, 1936.
15. Rose, Dean H., Wright, R. C. and Whiteman, T. M.—The Commercial Storage of Fruits, Vegetables and Florists' Stocks. *U.S. Dept. Agr. Circ.* 278, 1933.
16. Thompson, H. C.—Asparagus. *U.S. Dept. Agr. Farmers' Bul.* 829, 1917. Washington, D.C.
17. Thompson, R. C.—Asparagus Culture. *U.S. Dept. Agr. Farmers' Bul.* 1646, 1930. Washington, D.C.
18. Thornton, N. C.—The Effect of Carbon Dioxide on Fruits and Vegetables in Storage. *Contrib. Boyce Thompson Inst.*, 3, 219-244, 1931.

* * *

Avocados.

The avocado, also known as the avocado pear, ahuacate, zaboca, alligator pear, midshipman's butter, &c., is derived from several species of Persea (Lauraceae) indigenous to the West Indies, Central and South America, upwards of 400 varieties having now been recognised and named (2). In California (2, 10, 12) and Florida (23) the industry is extensive, large consignments of fruit being sent by rail to the centres of population throughout the United States. The fruit is also grown for export in Cuba (19), Porto Rico (6) and Hawaii (7, 8, 9, 26). Attempts to build up an export industry are now being made in British West Indian Islands (17, 20, 21). The fruit is prized for its rich nutty flavour and for its high oil and protein content. According to one authority (1) the avocado promises to become one of the five great food fruits of the tropics of both hemispheres within a generation.

Picking and Packing.

The maturity at which fruits are picked is determined by the length of storage life required, but immature fruits should be avoided as they tend to be inferior in flavour on subsequent ripening.

As avocado varieties show profound variations in respect of size, shape, colour, skin-texture and other characters, only local experience can prescribe the exact picking maturity for any particular variety. In California fruits are tested in the laboratory for oil content—which increases with maturity—as a means of determining when picking should take place, but this criterion, though helpful, is not absolute. Though fruit intended for storage is picked in a firm and inedible condition, nevertheless it must have reached a stage of maturity which will permit of normal ripening. Where a storage life of 20 to 25 days is required (*e.g.*, 14 to 18 days in cold storage during overseas transport, and seven to ten days for ripening and distribution) colouring varieties, *i.e.*, with red, purple or pale yellow skins, grown under West Indian conditions, may be picked when they show the first trace of colouring (20, 21). With green varieties the precise picking maturity is more difficult to determine and depends largely on personal judgment. The investigations of Stahl (18) indicate that specific gravity tests may be useful in determining picking maturity.

Picking is done by means of citrus clippers, the fruits being carefully placed in padded field boxes to avoid bruising during transport to the packing shed. In California and Florida the fruits are washed and graded by machinery for weight, and packed in single layers with excelsior in flat 13 lb. boxes, ten packing sizes being recognised according to the size and shape of the fruit. The ideal avocado for export has been described as a spherical fruit weighing approximately 1 lb.

In Florida the lug commonly used holds approximately 15 lb. of fruit, and has inside dimensions of $15'' \times 13'' \times 3\frac{1}{4}''$, $3\frac{3}{4}''$ or $4\frac{1}{4}''$ according to the size of the fruit. Tomato crates $12'' \times 12'' \times 24''$ (ventilated crates capable of holding about 40 lb.) may also be used, with a light wadding of excelsior to support the fruits and minimise bruising. Wrapping individual fruits and close packing with wood-wool, excelsior, &c., should be avoided to eliminate the tendency to self-heating. Where very mature fruit has to be railed long distances in hot weather, special crates bunkered with 12 to 20 lb. of ice according to the type of construction, are used (23).

Storage Temperature and Duration of Storage Life.

Among earlier investigations, Condit (3) reported that Mexican avocado varieties, cultivated in California, kept well for one month in cold storage but subsequently deteriorated through shrivelling and decay; the Challenge variety was stored satisfactorily at 32°F. for six weeks; softening

took place more rapidly in fruit held at 36°F. than at 32°F. Overholser (13, 15, 16) dealing with avocados grown in California, found that a temperature of 40°F. was satisfactory for all varieties tested except the Fuerte which required 45°F. to prevent blackening of the skin. In general a temperature of 32°F. was too low as it led to discolouration of the flesh, though indications were obtained that some varieties might be satisfactorily held at 32° to 35.6°F. Under proper storage conditions some varieties could be kept for approximately two months, others for five to six weeks, and others for four weeks. Quick storage after harvesting and care in handling improved the keeping quality of fruits. Fruits picked just before commencement of softening kept best and attained excellent quality.

As early as 1907 Higgins (8) in Honolulu referred to the successful export of avocados in cold storage to San Francisco (approximately seven days) with subsequent distribution by rail. More recently Harold (7) found that Hawaiian avocados may be stored green at 36°F. for six to eight weeks, thereafter ripening satisfactorily in two to five days. Wilcox and Hunn (26) have recorded the successful storage of Hawaiian avocados at 32°F. and 36°F., fruit having kept in good condition for periods up to 65 days.

Edwards and Guerrero (4) have described trial shipments of avocados between Guam, Marianne Islands, and Manila. The fruit, held at 40°F. during the voyage of 16 days, was discharged in good condition.

The earlier records dealing with varieties grown in the West Indies are scanty. Unsuccessful attempts to export fruit from Porto Rico are mentioned by Griffith (6) and Shill (17) has briefly described experiments with small lots of fruit held at 45° to 50°F. in Dominica with subsequent removal to tropical temperatures (average 85°F.). After being held in cold storage from six to ten days, the fruit, on exposure to the higher temperatures, ripened up with such rapidity as to make for considerable loss, internal blackening being a characteristic feature.

Californian fruit, if intended for the local market, is held in storage at ordinary temperatures until sufficiently soft for consumption. If required, fruit may also be held in cold storage at 40° to 45°F., some varieties having been kept in good condition for as long as two months (10). Fruit to be despatched by rail to eastern United States markets is pre-cooled at 40° to 45°F. for 48 hours and then placed in refrigerated cars, this class of fruit being still firm when it reaches the hands of the retailer. Provided it has been properly selected and treated, shipment to the eastern seaboard by way of the Panama Canal has also been shown to be a commercial possibility.

In 1933 and 1934 investigations conducted in Trinidad (20, 21) on upwards of thirty West Indian seedling varieties showed that only a few could be held at a temperature of 40°F. for 20 to 25 days without sustaining low temperature injury. On the other hand, a higher storage temperature, *e.g.*, 50°F. was found inapplicable because of the tendency of fruits to ripen before the required storage life had been achieved. These general conclusions referring to the storage of seedling varieties have been confirmed by work in Jamaica (25).

Even at relatively low temperatures, maturation processes slowly continue so that fruits ultimately become ripe and finally over-ripe. In the few varieties which are sufficiently cold-resistant or tolerant of low temperatures, such ripening apparently takes place in a more or less normal manner, the flesh at maturity being of good flavour and free from internal breakdown, discolouration or other obvious abnormalities. On the other hand, in the majority of varieties, *i.e.*, those which do not possess adequate cold resistance, maturation processes also continue but it is evident that the metabolic trend is abnormal. Thus although such fruits eventually become soft in cold storage, inspection of the flesh at once shows that chill effects have been induced. The range in genetical constitution exemplified by avocado varieties is strikingly demonstrated in the matter of cold-resistance: this extends from varieties subject to chilling after 15 days at 53°F. to those which ripen normally during 40 days at 40°F.

Chilling.

The possibility of developing an export industry in avocados in the West Indies and elsewhere where delicate varieties intolerant of low temperatures are cultivated, largely rests on the question of cold resistance. In varieties subject to chilling at 45°F. evidence of low temperature injury may be observed at an early stage, the flesh becoming discoloured while fruits are still hard and unripe: despite the presence of this pathological condition, however, such fruits continue to ripen, and ultimately become quite soft, with further accentuation of the internal discolouration. Short of killing tissues outright by freezing, therefore, it may be inferred that vital processes are involved both during the initiation and subsequent development of chill effects (20, 21, 22).

Various manifestations of chilling occur in fruit exposed to air-blast refrigeration. Necrosis of the skin in proximity to the stem-end, or brown, circular or confluent blemishes distributed over the skin, may sometimes be observed. Skin necrosis, however, is not usual, the large number of varieties showing internal chill effects being normal as regards external appearance. Internal chill effects are easily observed. While still firm, the flesh on cutting is seen to have acquired a slightly dark, smoky or brownish discolouration. In some varieties this is chiefly located next the stone, in others it may occur in the tissue mid-way between stone and skin. Again, in some instances the incipient chill symptoms may take the form of thin streaks as seen in longitudinal section, in others as isolated circular patches distributed towards the middle and distal regions of the fruit.

Chilling of the flesh becomes accentuated with the onset of final maturity and culminates in a more or less general discolouration of the entire tissue to a smoky-brown, chocolate-brown or black appearance. Low temperature injury has also been described as giving the flesh a greyish appearance. In Californian avocados, Horne (11) has described a darkening of the flesh sometimes associated with frost injury on the tree but in other instances due to other causes as yet uninvestigated.

In some varieties, either in conjunction with, or in the absence of discolouration of the flesh, the vascular strands which run longitudinally through the fruit may lose their clear, inconspicuous hyaline character and acquire a characteristic brown or blackish necrosed appearance by which they are rendered very conspicuous. In the matter of flavour, palatability in some varieties is only slightly impaired, whereas in others the nutty quality of the normally ripened fruit is replaced by a pasty, insipid flavour, or more or less acrid flavours may be induced.

Chilling is a complicated phenomenon in which various factors are involved. Among others the temperature and duration of storage are important: some varieties ripen normally after 20 days at 45°F. whereas during storage at this temperature for an additional ten days chill effects develop. The maturity of fruit at the time of storage is also of critical importance: fruits stored immature only show chill effects after long exposure to the low temperature, *i.e.*, after a certain stage in ripeness has slowly been reached, whereas fruits of the same variety stored more mature may show chill effects in a relatively short time. In general, the evidence available indicates that fruits are most subject to chilling during the initiation of ripening.

Gas-Storage.

Collectively the data obtained from gas-storage experiments show that by using subnormal concentrations of oxygen alone, or in conjunction with high concentrations of CO_2, a definite deceleration can be induced in the maturation of avocados. The range of tolerance to such treatments, however, varies from variety to variety, being comparable though not necessarily parallel to the response of different varieties to low temperatures. In varieties unsuited to gas-storage, external and internal damage may be sustained without the intervention of micro-organisms. In other varieties, although no direct physiological injury may be apparent, the fruits subsequently prove much more susceptible to the inroads of storage pathogens. Others, again, show surprising tolerance of gas-storage conditions and would undoubtedly lend themselves to commercial preservation by this method. It is interesting to note that in this category are varieties subject to chilling and consequently unsuitable for transport at low temperatures (20, 21, 22). Overholser (14) showed that Fuerte avocados which could only be held for ten days at 70° to 80°F., and for one month at 45°F., could be kept in good condition for two months at 45°F., provided they were maintained in an atmosphere of four to five per cent. oxygen and not more than four to five per cent. CO_2. Furthermore he observed that excessive concentrations of CO_2 did not result in the production of objectionable flavours, but prevented softening of the flesh, so that it remained tough even after removal from storage.

References.

1. Barrett, O. W.—The Tropical Crops. *The Macmillan Coy. New York*, 1928.
2. California Avocado Association. *Year Books, published Los Angeles, California.*
3. Condit, I. J.—*California Agr. Exp. Sta. Ann. Rept.* 1919.
4. Edwards, C. W. & Guerrero, J.—*Guam. Exp. Sta. Rept.* 1930.
5. Freeman, W. G.—The Avocado in Trinidad and Tobago. *Bul. Dept. Agr. Trinidad and Tobago*, Vol. XVIII, 3, 1919.
6. Griffith, J. P.—The Avocado. *Porto Rico Dept. Agri. & Labor. Circ. No.* 72, 1923.
7. Harold, E. V.—*Hawaii Agr. Exp. Sta. Rept.*, 1930.
8. Higgins, J. E.—Marketing Hawaiian Fruits. *Hawaiian Agr. Exp. Sta. Bul.* 14, 1907.
9. Higgins, J. E., Hunn, C. J. & Holt, V. S.—The Avocado in Hawaii. *Hawaii Agr. Exp. Sta. Bul.* 25, 1911.
10. Hodgson, R. W.—The California Avocado Industry. *Univ. Calif. Agr. Exten. Serv., Circ.* 43, 1930.
11. Horne, W. T.—Avocado Diseases in California. *Univ. Calif. Agr. Exp. Sta. Bul.* 585, 1934.
12. Jaffa, M. E., Goss, H. & Ryerson, K. Avocado Culture in California. *Univ. Calif. Agr. Exp. Sta. Bul.* 365, 1923.
13. Overholser, E. L.—Cold Storage Behavior of Avocado. *Calif. Avoc. Assoc. Ann Rept.* 1924-25.
14. Overholser, E. L.—Some Limitations of Gas-storage of Fruits. *Ice and Refrig.* LXXIV, 6, 1928.
15. Overholser, E. L.—Cold Storage, Ripening and Respiration Studies of the Fuerte Avocado. *Proc. Amer. Soc. Hort. Sci.* XXV, 1928, also *Calif. Avoc. Assoc. Year Book*, 1929.
16. Overholser, E. L.—Storage Responses of Some Common Fruits. *Amer. Inst. Refrig. Proc.* 17, 1928. *Exp. Sta. Rec.* LXIII, 745, 1930.
17. Shill, A. C.—Reports of the Marketing Officer 1931-32 and 1932-34 for Leeward and Windward Islands, B.W.I. *Trinidad Government Printers*, 1932. Also, Notes on the West Indian Fruit and Vegetable Trade in Canada. *Trinidad Government Printers*, 1932.
18. Stahl, A. L.—Changes in Composition of Florida Avocados in Relation to Maturity. *Univ. Florida Agr. Exp. Sta. Bul.* 259, 1933.
19. Tewell, H. S.—The Cuban Avocado Industry. *Calif. Avoc. Assoc., Year Book* 1934.
20. Wardlaw, C. W.—Preliminary Observations on the Storage of Avocado Pears. *Trop. Agriculture*, XI, 2, 1934.
21. Wardlaw, C. W. & Leonard, E. R.—The Storage of Avocado Pears. *Low Temp. Res. Sta. Mem.* 1, *Imp. Coll. Trop. Agr. Trinidad, B.W.I.*, 1935.
22. Wardlaw, C. W.—Notes on the Physiology and Biochemistry of Tropical Fruits. I. Avocados. *Trop. Agriculture* XIV. 2. 1937.

23. Wolfe, H. S., Toy, L. R. & Stahl, A. L.—Avocado Production in Florida *Univ. Florida Agr. Exp. Sta. Bul.* 272, 1934.
24. British West Indies Fruit and Vegetable Council (Eastern Group), St. Lucia, April, 1935. *Trinidad Government Printers*, 1935.
25. West Indies Fruit and Vegetable Bulletin. Vol. I, No. 1, May 1935. Also, Vol. I, No. 2, June 1936. Issued by *Imp. Col. Trop. Agr.* (For Official Use only).
26. Wilcox, E. V. & Hunn, C. J.—Cold Storage of Tropical Fruits. *Hawaii Agr. Exp. Sta. Press Bul.* 47, 1914.

* *

Bananas.

Bananas rank as one of the most important crops throughout tropical and subtropical regions and in some countries constitute the major source of agricultural wealth. In the course of a few decades, from small experimental shipments, a large and important export trade has developed in different parts of the world.

From the point of view of cold storage, the banana is in many ways unique even among tropical plants: it produces bunches all the year round, thereby obviating the need for storage over long periods; bunches are harvested quite green and for most markets less than full grown; they are transported for long distances, mostly without any crating or other protection, and are eventually ripened up in a few days under controlled conditions in specially constructed rooms. A knowledge of the correct stage of maturity for harvesting and the precise conditions for transport and ripening is essential to the production of attractively coloured, well-flavoured fruit.

As a rule the banana has to be transported over long distances before it is available for consumption in temperate lands. Not only is the bunch habit conducive to bruising, but the onset of final maturity can only be delayed to a certain extent by refrigeration. The fruit when approaching ripeness is very susceptible to fungal attack and, in consequence, considerable rotting may sometimes take place before the normal period of commercial handling has elapsed.

Varieties of Commerce.

The principal varieties of commerce are the Gros Michel, cultivated extensively in Jamaica and in Central and South America, and the Cavendish, Canary or Dwarf variety grown in the Canary Islands and Brazil for export to Britain and Europe, in Queensland for distribution in other parts of Australia, in Samoa for export to New Zealand, and in a number of African colonies and protectorates for export to Europe. The Lacatan (3), or Giant Fig variety, is exported in small quantities from Brazil to Europe. There is some trade in the Giant Governor between the French Antilles and France. Many other varieties, possessing great delicacy of flavour and texture, are also known but so far, because of transport and ripening difficulties, they have only been used for local consumption. The Red banana which is occasionally seen on British and American markets is chiefly valuable for decorative purposes; actually it is rather coarse and of mediocre flavour.

Classification of Fruit for Export.

In Central and South America and the West Indies, export bunches are divided into *classes* according to the number of "hands" or clusters on the stem and into *grades* according to maturity. A nine-hand bunch is taken as the standard, bunches of 8, 7 and 6 hands being priced at $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ respectively that of the standard or "count" bunch. In the Canary industry, a recognised system of lettering (*e.g.*, G, *gigantic*, Ex, *extra*, Esp., *especial*) indicates the type and quality of fruit contained in the crates. Other systems of classification are also encountered.

The usual grade of fruit shipped from Jamaican or Caribbean plantations to British and Continental markets is described as "standard" or "thin $\frac{3}{4}$-full"; less mature fruit is described as "thin"; for the more distant American markets fruit is reaped "heavy $\frac{3}{4}$-full" and for nearer markets "full". "Standard $\frac{3}{4}$-full" fruit is, as nearly as can be conveyed by verbal description, fruit which is beginning to fill out (so as to give a circular cross-section) but in which the ridges are still conspicuous. The less mature the fruit the longer, other things being equal, will be its storage life. If cut too immature, however, bunches ripen badly or not at all. In some varieties, *e.g.*, the Giant Governor, the size and appearance of the bunch, relative to the Gros Michel, are misleading as a guide to maturity. Thus, unless bunches are cut at a stage corresponding to "full" in the Gros Michel, they fail to ripen normally after the usual period in cold storage (16).

Organisation in the Banana Industry.

The banana industry is dependent for its success on a very elaborate but precise organisation. This may be illustrated by a simple example. In Central America a ship may leave with a cargo of 100,000 Gros Michel bunches, the total length of time elapsing between the commencement of reaping and the closing of the hatches being 36 hours or less. It is known that undue delay at this stage is liable to result in excessive wastage later.

On the plantations an exact schedule is followed so that reaping operations and local transport may be effected in the shortest possible time. Where wharfside facilities are available, mechanical elevators are used to charge the fruit into the holds. To convey the fruit to its destination, specially constructed ships with holds cooled by air-blast refrigeration have been designed. Finally, an efficient distributing system, involving the use of carefully controlled ripening rooms, ensures that fruit at the correct stage of maturity is constantly available to consumers in all parts of the country.

METHODS OF HANDLING FRUIT.

In handling bananas a number of different methods have been evolved. These fall into two definite categories in which the fruit—

(i) travels carefully packed in crates or other containers, or

(ii) is stowed "naked", or simply protected by a paper bag, in bulk.

(i) *Crated Fruit.*—The export of crated bananas is best exemplified by the industry in the Canary Islands (1, 6, 19). There the chief variety of commerce is the Dwarf, Canary or Cavendish variety, a plant yielding an attractive sweet fruit esteemed on British and European markets. Not only is the Canary banana very susceptible to bruising because of its thin skin, but the disposition of the individual fingers, and the shape of the bunch as a whole, contribute in a large measure to its liability to mechanical injury. For these reasons the export industry has been developed on a system of careful handling, packing and crating.

To ensure the production of attractive fruit for export, the bunches receive attention from the time they are "shot" or "born" in the plantation. As soon as the young bunch (inflorescence) emerges, the number of the month is stamped on the stalk to facilitate estimating the time of maturing. The large bracts associated with the hands, the perianth-remains, and the terminal bud of male flowers, are removed at an early stage to get rid of potential sources of fungal infection. In due course, as the bunch becomes heavy, a strut is inserted under the slightly inclined trunk to give it support. The bunches of fruit are carefully reaped and conveyed by various means, on the head, on pack animals, or even on aerial rope-ways, to packing sheds. There the bunches are graded and packed into wooden crates or cardboard drums. The hexagonal crates are usually lined with straw or banana trash (old dried leaves); the bunch, wrapped in cotton-wool and covered with paper, is then carefully placed in position and firmly fixed by pressing the straw or trash around it. The slatted top of the crate is then nailed down. Such crates may contain one or several bunches. When three bunches are being crated together two are placed parallel and one transversely. Packing fruit in cardboard drums is used chiefly in the export to Spanish markets where less handling is involved.

The crating adopted in the Canary Islands entails considerable expense. On the other hand, wastage due to mechanical injury and fungal activity is at a minimum. Further, as the period of ocean transport is relatively short, consignments of fruit can be stowed as ordinary cargo without refrigeration. In Britain the bunches are usually allowed to ripen in the crates, but on the Continent it is the customary practice to hang them up for ripening.

In Martinique and Guadeloupe large cases 1.5 m. by 1.25 m., padded with straw and capable of holding 24 wrapped bunches (weighing 600 kg.) have also on occasion been used for the Giant Governor and Cavendish varieties.

The Canary Islands system, more or less modified, has been adopted in Italian and French Somaliland, French Guinea and the French Antilles where the Cavendish is also the variety of commerce.

In Queensland, where the industry is also based on the Cavendish variety, fruit for local consumption is handled in the bunch. Bananas intended for the southern markets, on the other hand, are cut from the bunches and packed in wooden cases for transport by rail. The fruit, packed as "hands", "clusters" of about four fingers, or "singles" (this is the most common method), is ripened without removal from the case.

> "The hands are cut from the bunches and the individual fruits are cut or broken off and packed into paper-lined cases. The cases which measure internally 24¾ ins. by 12 ins. by 12 ins., have solid ends, and sides composed of two or three pieces of wood fitting closely together. The top and bottom are formed of two or three slats with gaps at the edges and between them, of about ½ inch. In packing, the paper lining closes up these openings unless, as is customary in summer, it is torn at the gaps after the lids have been nailed down" (18).

The cases are then sent by rail to Sydney, Melbourne and Adelaide, journeys of approximately two, four and five days respectively. There is also some trade to Western Australia, chiefly by boat from Melbourne, making a total journey of 11 days. Consignments are also carried on the trans-continental railway, a total journey of ten days. The bananas on arrival in the southern cities are still green and must be ripened artificially. The overland transport of crated fruit, during summer and winter, from Queensland to other parts of Australia has its own particular problems and difficulties. These have been the subject of official investigations (4, 18) but their specialised nature precludes discussion here.

The advantages of the Queensland system are those of economy of packing and freight, the utilisation of fruit from small bunches, and the carriage of varieties in which the finger is too readily detached from the stem for transport in whole bunches. The disadvantages lie in the more rapid and uneven ripening of consignments and the higher incidence of fungal wastage due to pathogens gaining access through the cut finger stalks (*i.e.*, "black-end" or "finger-stalk" rot (5) and "squirter" disease (8, 9)). It has been suggested that, to some extent, wastage might be curtailed by precooling the bunches prior to the cutting or breaking off of the fingers and packing in pre-cooled crates (13).

In the export industry from Samoa to Wellington, New Zealand, the fruit is packed as "singles" in cases containing approximately 90 lb. During the ocean voyage of 11 days, although the holds are refrigerated, this method of handling may lead to a considerable amount of wastage.

Bunches for export from Formosa to Japanese markets are cut up into hands and packed in bamboo baskets giving a pack of approximately 100 lb. weight.

(ii) *Transport of "Naked" Fruit.* — The extensive export industry from Caribbean bananalands to American and European markets is based on the Gros Michel banana. Not only has this variety a sufficiently tough skin to withstand the bruising consequent on normal handling but its strikingly cylindrical bunch habit enables it to be stowed "naked" in bulk without undue loss resulting from mechanical injury. Crating is precluded by high labour and freight charges, and by the enormous quantities of fruit shipped. On some plantations, however, all bunches are enclosed in stout paper bags in order to minimise mechanical injuries. The supremacy of the Gros Michel in the world's markets is due to its suitability for transport in bulk, and its good appearance and flavour on ripening.

Following the lines successfully adopted in Caribbean banana plantations, an industry using the Dwarf Cavendish (or Canary) and Giant Fig varieties has been inaugurated round the port of Santos in Brazil (2, 10, 12). Prior to reaping, paper pads containing trash are inserted as required between the first, second and third hands; a stout perforated paper bag is then slipped over the bunch and tied at the neck. The bunch is harvested and shouldered or headed out to the nearest tram-line. From there bunches are conveyed to the riverside, where they are loaded on to specially built barges. The latter are then towed down the rivers or along the coast to the ships. Loading is achieved by means of mechanical conveyors, or, if the ship is lying out at sea, by large basket crates operated by the ship's winches. Stowage is in bulk as described below for the Gros Michel, refrigeration being supplied in the form of a cold air blast.

For Cavendish fruit grown in the Canary Islands, French Guinea, Guadeloupe and Martinique, the stout paper bag is not considered adequate for the protection of bunches, and a more elaborate wrapping in cotton-wool wadding, kraft-paper and straw has been adopted (Kervegant). A somewhat similar protection is given to fruit exported from Hawaii to the United States.

Handling and Stowage of Large Consignments.— Practical experience and scientific investigation have shown that it is of the utmost importance to reduce to the minimum the time between reaping fruit and charging it into the holds and commencement of refrigeration. This is usually 36 hours or less. The importance of exact shipping schedules and shore organisation has already been emphasised. Before being loaded into the holds, bunches are inspected on the wharfside and all undesirable ones rejected. In some instances the stem-ends are retrimmed and treated with a fungicide to minimise rotting by fungal organisms (11, 13, 15). Bunches which pass the inspectors are placed on specially designed, adjustable conveyors which, working on the endless-belt system, carry the bunches into the holds. There they are removed by a gang of workers and stowed compactly in the bins into which the hold space is divided. As a rule, two or three tiers of fruit are stacked with the bunches — large end downwards—in a vertical position; a top layer occupying a more or less horizontal position, is used to fill up any remaining space. As soon as a hold is charged the hatches are closed and sealed and refrigeration is commenced.

Conditions during Overseas Transport.

Bananas cut approximately "$\frac{3}{4}$-full", if left at tropical temperatures, would ripen up in the course of five to eight days. Refrigeration is accordingly, essential to the overseas transport of the banana, firstly to delay ripening and senescence, and secondly, to curtail the activity of rot-producing organisms.

Cooling of fruit is achieved by means of air-blast refrigeration, the holds being precooled prior to stowing the cargo. Experience has shown that 53°F. is the temperature best suited to the storage of $\frac{3}{4}$-full Gros Michel bunches where the period of ocean transport is about 16 to 18 days. This temperature should be attained as quickly as possible so as to check the activity of fungi, but it is important that the delivery air temperatures should not fall below 53°F. or the fruit will be chilled. Once or twice per day, according to requirements and opportunity, the air circulating in the holds is completely blown out, so as to avoid adverse effects which might result from the excessive accumulation of carbon dioxide or volatile substances. Fruit intended for the nearer American ports is exported from the Caribbean region in ventilated holds without refrigeration.

The relative humidity in fully charged banana holds is usually high, ranging from 80 per cent. almost to saturation. Sometimes it is in the region of 95 per cent.—a degree of humidity which encourages the superficial growth of moulds and mutual contamination of fruits. From the point of view of wastage control, therefore, a reduction in the relative humidity would be advantageous provided it was not such as to cause excessive dehydration with concomitant shrivelling (10, 15).

During transport, the banana holds are inspected daily by the ship's officers and all bunches showing evidence of ripening are removed. Otherwise accelerated ripening of green bunches by volatile substances given off by the ripe fruit may be experienced.

Storage Temperature.

Precise knowledge of the carrying temperatures best suited to different varieties and grades of fruit is essential to avoid chill effects.

For the Gros Michel it has been shown (14) that chilling was not produced by:

(i) cooling to 52°F., no matter how rapidly, provided the temperature of the delivery air was not below 52°F.;

(ii) exposure of fruit to 52°F. for 4 days and then to 53.6°F. for 4 days and then to 53.6°F. for 11 days;

(iii) exposure of fruit to 53.6°F. for as long as 24 days.

From storage trials conducted at 51° to 52°F. it was found that chilling is a cumulative effect of duration of exposure, and is not the result of rapid cooling to such temperatures. In practice the Gros Michel banana is usually transported at a temperature of 53°F., and may be cooled to this temperature as quickly as possible, provided the delivery air does not fall below this temperature.

From studies conducted on fruit grown in Trinidad the Dwarf or Cavendish variety appears to be slightly more cold resistant than the Gros Michel (14). The Lacatan (or Giant Fig) and the Congo on the other hand, are less cold-resistant and require a hold temperature of 58° to 60°F. in order that chill effects may be avoided (13). For the Giant Governor the storage temperature lies in the vicinity of 56° to 58°F. (16). The hybrid varieties I.C.1 and I.C.2, bred from the Gros Michel as female parent and a wild seeded variety as male parent, behave like the Gros Michel in cold storage (13, 16). The Red banana carries well in storage at 53°F. (13). A variety known as Fillbasket ripens well after being stored at 53°F. (16).

Symptoms of Chilling.

Certain physiological maladies, such as "green-ripeness"—as the name implies, the yellow skin-colour is poorly developed while the pulp within is soft and fully matured—may be caused by too high ripening temperatures*. More commonly, however, the physiological diseases of commerce are due to "over-refrigeration" or chilling on shipboard.

In green bananas chilling may be difficult to recognise externally; it has been identified in a general way by an increased development of brown streaks in the sub-epidermal tissues, this characteristic colouration being associated with the mucilage ducts. During ripening, chilling is easily recognised by several abnormalities (14):

(i) delayed ripening, and, in severe cases, complete failure to ripen;

(ii) hardening of the central placenta—more pronounced in the Cavendish than in the Gros Michel;

(iii) assumption of a dull yellow colour instead of a healthy bright one; in the Gros Michel, as ripening proceeds, the dull yellow is replaced entirely by a dull russet colour, which later darkens; a dark mottling, associated with desiccation of the tissues, may also occur; this russetting of the whole bunch has not been noticed in the Cavendish, even when kept for 50 days at 52°F.; (in point of fact, it is sometimes rather difficult to recognise chilling in this variety, as fruit picked at an immature stage shows, on ripening, hardness of centre, dullness of colour, a tendency to browning—not typical Gros Michel russetting—characteristics which might be mistaken for chill effects; when definite chilling is produced in Cavendish types, including the Lacatan and Giant Governor, it is readily recognised during ripening at 70°F. by the assumption of a dull, sooty, ashen colour; green fruits also show a characteristic browning, particularly in the region of wounds or abrasions);

(iv) complete loss of banana flavour or the presence of a strange "cold-storage flavour";

(v) "green-ripeness" and "hard-ripeness" (14).

Limits of Chilling.

The following experimental treatments have yielded evidence of chilling:

(*a*) *Gros Michel*, (i) exposure of 14 days at 52°F.; (ii) exposure of nine days at 51°F.;

(*b*) *Cavendish*, exposure of 13 days at 51°F.

Provided standard fruit is used, chilling can readily be avoided by paying attention to the temperature of the air-blast at the delivery side. The fact that rapid cooling to 53°F., by delivering air at that temperature, can be practised without danger of chilling permits of wastage control by curtailing fungal growth.

It has been found (16) that heavy ¾-full Gros Michel bunches are more susceptible to chilling during long ocean voyages than standard ¾-full, and that the Giant Governor and Lacatan varieties are subject to chilling at temperatures below 56° to 58°F. Olney (8A) has recorded chilling as occurring in Gros Michel bunches (imported into the United States and therefore most probably heavy ¾-full) held at a temperature of 54.6°F.

*At high temperatures, 80°-90°F., the banana ripens rapidly but abnormally. The rate of carbon dioxide production increases rapidly and then falls rapidly. The skin does not develop the full yellow colour of normal ripe fruit but becomes dull yellow and later the dark-brown areas which appear become infected by fungi. The pulp is soft and watery. In this condition, sometimes experienced in Australian markets when fruit has been subjected to high temperatures, the fruit is said to be "boiled."

Young *et al.* (18), experimenting with the Cavendish variety in Australia (Brisbane) obtained the following data on susceptibility to low temperature injury.

(*a*) Storage at temperatures down to 45°F. for four days did not in any way affect the appearance of green bananas.

(*b*) Storage at 50°F. for periods up to four days caused a delay of up to one day in the subsequent colouring of the bananas, but apart from this there was no appreciable effect on the ripening.

(*c*) Storage at 45°F. for two days caused a delay in colouring of about one day, but apart from this there was no appreciable effect on the ripening of the fruit.

(*d*) Storage for four days at 45°F. had no appreciable effect on the subsequent ripening of the pulp of the bananas, but it caused a considerable delay in the colouring, and the fruit had a definitely greenish colour when fully ripe.

(*e*) Storage at 33°F. for 1½ days, or at 40°F. for 3½ days, produced a definite change in the appearance of the green bananas.

(*f*) Storage at temperatures below 45°F. had a more marked effect on the subsequent colour development than storage at 45°F., and it also tended to reduce the life of the fruit after ripening.

The cooling necessary to bring about "chilling" appears to vary with the temperature conditions under which the fruit is grown, winter-grown fruit being considerably less affected by low temperatures than summer-grown fruit. On the other hand, winter-grown fruit is more sensitive to high temperatures in the ripening rooms than summer-grown fruit.

Chilling has usually been attributed to exposure to cold conditions during transport, but it appears that a considerable proportion of it is due to exposure to low temperatures on the plantation, probably before the fruit is cut from the plant (18.)

Collectively the observations set out in this section indicate that, during the overseas transport of fruit, it is not only necessary to apply refrigeration at the tropical end but, during winter, it may be necessary to supply heat to the holds as the temperate regions are approached. In modern ships provision is made for this contingency.

The Effect of Quality on Storage and Ripening.

The quality of bananas varies considerably according to variety, the conditions under which they have been grown, and the procedure adopted during storage and ripening. Thus although the Gros Michel is the principal variety of commerce, it is not the variety most esteemed by connoisseurs, the Cavendish being preferred for ts more sugary pulp and the Lacatan for its aroma, texture and sweetness. There are also many varieties used for local consumption throughout the tropics compared with which the Gros Michel is a relatively coarse fruit.

Within any one variety, such as the Gros Michel or Cavendish, considerable variation in quality may also occur. Thus the Cavendish variety as grown in the Canary Islands is a relatively small, sugary fruit whereas, under the moist tropical conditions in the Caribbean region, the fruit is much larger and, according to general opinion, of poorer flavour.

The size of the fruit grown in any one locality cannot always be taken as an indication of quality but in general it may be accepted that large bunches of fruit are usually of good quality and keep better during storage than small bunches; the appearance on ripening is also better. In Australia it has been found that poor quality fruit requires more careful treatment in the ripening rooms than good fruit. It has been shown, for example, that poor fruit is more adversely affected by high temperatures than is good material (18). In chilling experiments conducted in Trinidad (14) indications were obtained that large, vigorous bunches were less susceptible to low temperature injury than poorer bunches. In Queensland it has been found that Cavendish bananas grown on a shale or clay soil deteriorated much more quickly and were generally inferior to fruit grown on good soils of volcanic origin.

Wastage in Banana Shipments.

Wastage, sometimes very considerable, is a feature of all banana shipments. From the time of cutting bunches are subject to the inroads of a large number of fungal organisms. Some of these have already been established during development, and remain as latent infections until the fruit is entering on the final phase of maturation. A large number of the fruit-rotting fungi, however, gain access through the various cuts and bruises inseparable from reaping and transport operations. These develop slowly during the cold-storage transport period and rapidly when the fruit is taken to the higher temperatures prevailing in ripening rooms. Delay in applying refrigeration to harvested bunches greatly accelerates the onset and intensity of wastage. Hence the recommendation that the time between reaping of bunches and cooling to 53°F. be curtailed to the minimum (13). The several aspects of disease, attributable to a varied and extensive fungal flora, have been classified as follows: main-stalk rot; cushion infections; finger-stalk rot; and finger diseases.

In the matter of fungal wastage the Cavendish and Lacatan (Giant Fig) varieties are considerably more susceptible than the Gros Michel. A seasonal drift may sometimes be observed in the incidence of rotting, as in Brazilian Cavendish consignments (10). Other factors, including those of soil and climate, also predispose fruit to a greater or less susceptibility to the several

pathogens. Manurial treatment may also be important. Thus when the Cavendish variety is grown on poor soils with the help of fertilizers in Trinidad, the tendency of bunches to suffer from mechanical injury and fungal penetration is greatly accentuated (16). Cargoes which have been chilled *en route* show increased fungal wastage during subsequent ripening.

Transport by Land.

On arriving at the port of destination, the fruit is discharged by means of mechanical conveyors, and is placed in specially constructed fruit cars or waggons for distribution. Where refrigeration is necessary, as in the United States, the waggons are maintained at a temperature of 54°F. Attention has already been directed to the special conditions of overland transport involved in the Queensland banana industry (18).

Ripening.

On being discharged from the holds, the bunches, still mostly green, have next to be ripened. This is done in special ripening-rooms usually at a temperature of 66° to 68°F. or less according to the demand for ripe fruit. Each bunch is suspended with the lower or distal end uppermost by a rope attached to the ceiling. Fruit which is ripe or nearly ripe on being discharged from the holds is retailed immediately. In well-equipped modern ripening rooms the installation includes apparatus for the control of temperature and humidity.

At the time of reaping the storage material in the green banana is almost entirely starch, approximately 30 per cent. by weight being present, as against only 0.7 to 0.8 of sugars. Ripening is characterised by many changes, including the yellowing of the skin, the transformation of all or practically all the starch into soluble sugar, the oxidation of tannins, the softening of the fruit, the transformation of insoluble pectose(protopectin) into soluble pectin, and the production and liberation of various volatile substances which give the ripe fruit its characteristic aroma and flavour. Later, when the fruit is tending towards the over-ripe condition, the skin becomes covered with a dark brown mottling and alcohol begins to accumulate in the pulp. At this stage the fruit is usually exploited by various fungal pathogens. The rate at which these changes take place depends chiefly on the maturity of the fruit and the temperature of the ripening room but other factors are also involved.

Ripening Temperatures.—Reynolds cites the following temperatures for fruit received in the United States of America :—

56°F. ..	..holding ripe fruit.
58°F. ..	..holding green bananas.
62° to 66°F.	..normal ripening.
68°F. ..	..forced or fast ripening.
72°F. ..	..danger of cooking.

These values refer, of course, to the heavier grades of Gros Michel fruit. For standard ¾-full bunches received in Britain, normal ripening temperatures range from 60° to 70°F., according to circumstances, a starting temperature of 68°F. being commonly used.

In Australia, green Cavendish fruit may be stored, during the summer months, in ripening rooms for three days at temperatures of 53° to 58°F. provided the atmosphere is quite free from ethylene ; partially ripe, cased bananas may be held for three days at 55° to 60°F. during which time they colour slowly but remain in good condition for some time after removal. Uncrated fingers or fruit in the bunch should not be cooled below 62°F. During the winter months (average air temperature 50° to 60°F.) green bananas may be stored for periods up to seven days outside the ripening rooms in any dry place, provided no traces of coal-gas are present.

As a rule, during the earlier stages, a high R.H. (85 per cent.) is maintained in the ripening rooms, but once the fruit is " sprung", *i e.* showing a definite yellowing and signs of active ripening, the R.H. is reduced to 70 to 75 per cent. to harden the fruit and to curtail the activities of superficial fungi. If the humidity is too low, evaporation from the fruit tends to be excessive and as a result the peel develops a poor colour and a somewhat withered or desiccated appearance. The quality of the ripe fruit may also suffer. During the hardening period at a lower R.H. the temperature may also be reduced. Bananas ripened at a high temperature —temperatures of 72° to 85°F. are sometimes used to force ripening —are of poorer flavour and tend to deteriorate rapidly. Where high temperatures are used the period of exposure should be very brief, 12 hours or less. High relative humidities (above 85 per cent.) are also to be avoided, particularly where cased fruit is being ripened. The following Table, based on crated fruit (Australian) held in ripening rooms at 68°F., shows the effect of high humidity on the temperature of cased bananas.

Australian Cavendish Variety (Crated).

(*After Young, Bagster, Hicks and Huelin*).

Temp. of room.	Humidity %	Case temperature after 2½ days.
68°F.	80	76.0°F.
68°F.	85	77.2°F.
68°F.	90	78.5°F.

These differences are attributable to the fact that the increased humidity causes less transpiration from the fruit with a reduction in the cooling effect due to evaporation.

The Cavendish variety suffers from exposure to high temperatures in the ripening room, yielding an ultra-soft fruit of unpleasant flavour, odour and colour (pale greenish yellow) generally described by the trade as *boiled*. The ripening of this variety in Australia has been made the subject of intensive research (18). For practical purposes the following stages of ripeness have been described:

(i) hard green; (ii) sprung, *i.e.*, when the fruit still appears hard and green but has gained a definite flexibility; (iii) colour shows, *i.e.*, when the first tinges of yellow appear; (iv) half colour, *i.e.*, when the green and yellow both appear; (v) green tip, *i.e.* when the fruit is full yellow except at the extreme flower end; sometimes there is no definite "green tip" stage, the fruit colouring evenly to yellow; (vi) full colour; there is sometimes some persistence of green at the flower end, but a fairly definite "full colour" stage can always be recognized; (vii) full ripe, *i.e.*, clear yellow with signs of dark marking (flecking); (viii) flecked, *i.e.*, markings well developed; (ix) deteriorating, *i.e.*, when pulp begins to soften (18).

In general, a temperature of 68°F. has been found suitable for the ripening of the Cavendish variety as grown under Australian conditions. But because of differences in the quality of fruit from different areas, production under summer and winter conditions, &c., a considerable elaboration of the ripening technique, involving the use of ethylene or unburnt coal gas as an accelerant, has been found necessary. For a full account the reader is referred to the original memoir of Young and his colleagues (18). The following Table summarises their recommendations as to the procedures to be adopted.

Accelerated Ripening.—It has been found that traces of ethylene, one of the ingredients of coal-gas, exercise an accelerating action on the ripening of various fruits, including the banana (17). It has also been shown that various fruits give off volatile substances, now known to include ethylene. Hence arises the action of ripening or ripe fruit in promoting the maturation of green fruits in close proximity and the need for eliminating volatiles from the atmosphere of storage rooms or holds in which fruit has to be maintained in the green condition (7). When quick ripening is required, however, ethylene or unburnt coal-gas, in very small concentrations, as indicated in the Table above, may be used to advantage on a commercial scale. Indeed, it has been found impossible to ripen Queensland Cavendish varieties satisfactorily unless traces of accelerating substances are present in the atmosphere of ripening rooms (18).

	Brisbane (Bunch Fruit).	Brisbane (Cased Fruit).	Melbourne (Cased Fruit).
1. Summer conditions			
Temperature	68°-70°F.	68°-70°F.	68°-70°F.
Humidity	85% reducing to 70%	85% reducing to 70%	85% reducing to 70 %
Unburnt gas concentration	1 part per 1,000 added twice daily.	1 part per 1,000 added twice daily.	1 part per 1,000 added twice daily.
Time of reduction of humidity	"Spring" stage.	"Colour shows" stage.	"Colour shows" stage.
Time of removal	Not before "half colour" stage.	Not before "half colour" stage.	In hot weather at "colour shows" stage or later. In mild weather whenever convenient.
2. Winter conditions (May to September)			
Temperature	66°-68°F.	66°F.	66°F.
Humidity	85% reducing to 70%	95% reducing to 70%	85% reducing to 70%
Unburnt gas concentrations	3 parts per 1,000 added twice daily.	3 parts per 1,000 added twice daily.	3 parts per 1,000 added twice daily.
Time of reduction of humidity	"Colour shows" stage.	When case temperature reaches 73°F. but not later than "colour shows" stage.	When case temperature reaches 73°F. but not later than "colour shows" stage.
Time of removal	Not before "half colour" stage except in mild weather.	Not before "half colour" stage.	Not before "half colour" stage, and preferably later in cold weather.

General References.

Fawcett, W.—The Banana, its Cultivation, Distribution and Commercial Uses. *London, Duckworth & Co.*, 2nd. ed. 1921.

Kervegant, D.—Le Bananier et son Exploitation. *Paris Societe D'Editions Geographiques, Maritimes et Coloniales*, 1935.

Reynolds, P. K.—The Banana, its History, Cultivation and Place among Staple Foods. *Boston Houghton Mifflin Co.*, 1927.

Ruschmann, W.—Banane. *Hamburg, Deutscher Auslandverlag.*

Wardlaw, C. W. — Diseases of the Banana. *Macmillan & Co., London*, 1935.

References Cited in Text.

1. Appert, M.—Le Bananier a la Grande Canarie *Agronomie Col.* XXIII, 136-145, 173-186, 1934.
2. Aspinall, A.—Brazilian Bananas. *West India Comm. Circ.* XLII, 405, 1928.
3. Cheesman, E. E., Wardlaw, C. W. & Spencer, G. L.—The Cavendish Group of Banana Varieties with Special Reference to Lacatan. *Trop. Agriculture*, X, 8, 1933.
4. Hicks, E. W. & Holmes, N. E.—Further Investigations into the Transport of Bananas in Australia. *Counc. Sci. Ind. Res. Australia, Bul.* 91, 1935.
5. Hoette, S.—Certain Aspects of Investigation on Black-end Disease of Bananas in Australia. *Counc. Sci. Ind. Res. Australia, Pam.* 58, 1935.
6. Holmes, E.—The Canary Banana. *Trop. Agriculture* VII, 12, 1930.
7. Kidd, F. & West, C.—The influence of carbon dioxide, oxygen and rate of ventilation upon the storage, ripening and respiration of bananas. *Dept. Sci. Ind. Res., Food Invest. Bd. Rept.* 103-108, 1931.
8. MacLennan, E. J. & Hoette, S.—Nigrospora musae n. sp. and its Connexion with Squirter Disease in Bananas. *Counc. Sci. Ind. Res. Australia, Bul.* 75, 1933.

8A. Olney, A. J.—Temperature and Respiration of Ripening Bananas. *Bot. Gaz.* LXXXII, 1926.

9. Simmonds, J. H.—Squirter Disease of Bananas. *Queensland Agr. Jour.* 98-115, 1933.
10. Tomkins, R. G.—Wastage in Banana Transport. *Trop. Agriculture*, VIII, 10, 1931.
11. Tomkins, R. G. & Woodman, R. M.—Stalk Treatment of Fruit and Vegetables for the Prevention of Stalk Rot, with Special Reference to Bananas. *Jour. Soc. Chem. Ind.*, XLIX, 1930.
12. Wardlaw, C. W. & McGuire, L. P.—Cultivation and Diseases of the Banana in Brazil. *Trop. Agriculture*, X, 192-197, 211-217, 255-259, 1933.
13. Wardlaw, C. W. & McGuire, L.P.—The Behaviour and Diseases of the Banana in Storage and Transport. *Emp. Mark. Bd. Rept.* 36, 1931. H.M.S.O.
14. Wardlaw, C. W. & McGuire, L. P.—Transport, and Storage of Bananas with Special Reference to Chilling. *Emp. Mark. Bd. Rept.* 45, 1931. H.M.S.O.
15. Wardlaw, C. W. & McGuire, L. P.—Control of Wastage in Bananas with Special Reference to Time and Temperature Factors. *Emp. Mark. Bd. Rept.* 60, 1932, H.M.S.O.
16. Wardlaw, C. W. and McGuire, L. P.—Banana Storage. An Account of Recent Investigations into the Storage Behaviour of Several Varieties. *Emp. Mark. Bd. Rept.* 72, 1933. H.M.S.O.
17. Wolfe, E. S.—Effect of Ethylene on the Ripening of Bananas. *Bot. Gaz.* XCII, 1931.
18. Young, W. J., Bagster, L. S., Hicks, E. W. and Huelin, F. E.—The Ripening and Transport of Bananas in Australia. *Counc. Sci. Ind. Res. Australia, Bul.* 64, 1932.
19. Banana Cultivation in the Canary Islands. *Bul. Imp. Inst.* XXIII, 169-174, 1925.

NUTRITION STUDIES WITH CORN.

I.—A Statistical Interpretation of the Nutrient Ion Effect Upon Growth in Artificial Culture.

J. R. Beckenbach, C. H. Wadleigh and J. W. Shive. *Soil Sci.*, Vol. XLI, No. 6, 1936, p. 469.

A system of physiologically balanced solutions is presented in which it is possible to vary the concentration of any or all of the individual ions, and to isolate the effect of any ion or combination of ions upon plant growth, as measured by average green weight per plant. The series of solutions was used in the growth of a strain of hybrid corn, and the growth of the plants was used as a means of comparison of the effects of the ions. A statistical analysis was employed with the data obtained, and the following conclusions were drawn from a consideration of the indexes of part correlation and of the net regression curves.

(1) No correlation was observed between the amounts of SO_4 or PO_4 in the substrate and the growth of the plants within the limits of the concentrations employed.

(2) Increasingly high concentrations of NO_3 in the substrate, between the limits of one and eight out of a total of ten relative parts of the anion concentration, gave the most marked correlations with increases in growth.

(3) Increasingly high concentrations of both K and Ca, between the same concentration limits, gave marked increases in growth.

Increasingly high concentrations of Mg, between the same limits, resulted in decreased growth, producing symptoms of toxicity in the high concentration utilised. The net regression curve had a negative slope within the limits of the variation of the Mg supply in the substrate.

The importance of the relative concentrations of the cations is entirely dependent upon the amount of NO_3 present in the substrate. At *low* concentrations of NO_3 little importance can be attached to the relative proportions of the three cations. At *higher* concentrations of NO_3, the necessity for higher relative proportions of K and Ca, and for lower relative proportions of Mg in the substrate for maximum response to the NO_3, is brought out. With high concentrations of both Mg and NO_3, the toxicity of the Mg is particularly noticeable in the manner in which it inhibits the growth of the plants. None of the three cation ratios, Ca/Mg, K/Mg, or K/Ca, shows any significance in these experiments. The dry weight data show correlations between the percentage of dry weight and relative concentrations of three of the major nutritional elements. The higher the available relative amounts of both NO_3 and K, the lower the percentage of dry weight of the tissues produced. With increasing Ca concentration in the medium, there was a higher percentage of dry material in the tissues.

A NEW DISEASE OF CACAO IN THE GOLD COAST.*

A new disease of cacao, provisionally named "Swollen Shoot and Die-back" has recently been found in the Gold Coast where it is said to be widely distributed in the New Juaben district, Eastern Province. The disease, the cause of which has not yet been definitely established, gives rise to characteristic smooth swellings of young shoots and eventually the tree is killed. According to the Plant Pathologist "the first sign of the disease is an irregular thickening of the chupons (young growing shoots) in which regions of abnormal swelling are separated by constrictions. The constricted parts vary from one to several inches in length, and may be less than ¼ in. thick, while the thickened parts may attain a thickness of more than one inch, even in very small chupons, and are usually about equal in length to the constrictions. The transition from the swollen parts to the constricted is gradual. Such shoots may be observed on otherwise healthy trees.

The second and more serious symptom of the disease is a general defoliation and dying back of the tree, which appears to affect all parts simultaneously. The leaves drop off, and the young deformed chupons dry out and shrivel, the growth of the pods ceases, and the whole tree dies. The roots of such a tree appear to be perfectly normal and healthy except for the occurrence of occasional swellings similar to those seen on the young chupons.

The disease occurs in patches in an otherwise perfectly normal farm (about 20 years old) and trees in the early stages of the disease have been observed on the borders of those patches of dead cocoa. There is therefore some evidence that the disease spreads in a radial fashion from a central point. The largest patch observed was about 30 yards in diameter, which size it has attained in the space of approximately two years. Young seedlings planted in the affected area are showing symptoms similar to those seen in the chupons of the old trees".

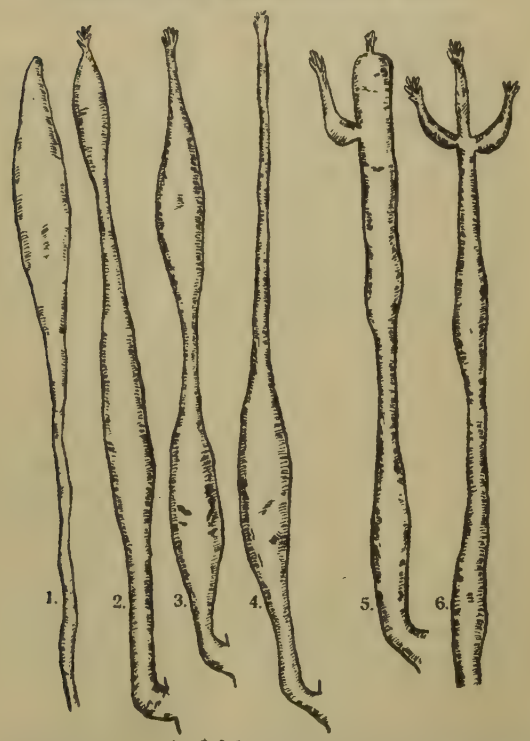
The incidence of the die-back has been recorded in areas where soil conditions appear to be excellent and where undue exposure cannot be said to exist. These facts give a clear indication that the disease may be serious and that, unless checked, it may in time considerably reduce the cocoa crop in the areas where it occurs.

Work on the disease has so far been mainly confined to a search for a parasite capable of producing in young cocoa shoots the symptoms described above, together with a close study of the symptoms themselves. A fungus which, given suitable conditions, is thought to be capable of producing the observed symptoms has actually been isolated from many young infected shoots, and further study has strengthened the suspicion that this fungus is the probable cause of the disease. If this tentative conclusion is confirmed by further work it will definitely place the disease in the category of "Wither-Tip" diseases—the causes of serious damage to several other crops, and against which effective control measures have in a number of instances been applied.

Control measures proposed in the present case are simple but will involve the use of a considerable amount of labour which in the early stages, at least, will be supplied by the Gold Coast Department of Agriculture. In brief it is proposed to cut out and burn all diseased trees, together with a few of the apparently healthy trees at the edge of each diseased area since such trees may already have become infected. Owners of the farms concerned will be compensated for the loss of these healthy trees.

Where trees are removed it is further proposed to plant up windbreaks in order that the remaining cocoa shall not suffer unduly from the exposed conditions produced. Food-crops will be grown on the land so treated for at least one year, after which new cocoa may be planted by the farmers. It is hoped by these means to stop the spread of the disease before it seriously reduces the cocoa crop in the affected areas.

SWOLLEN SHOOT AND DIE-BACK OF CACAO.*



1. *Growing Tip Affected.* 2. & 3. *Growing Tips and Bases Swollen.*
4. *Bases Swollen.* 5. & 6. *Branching of infected Growing Tips.*

* Reproduced from *The Gold Coast Farmer*, Vol. V, No. 8, Dec., 1936.

* From *The Gold Coast Farmer*, Vol. V, Nos. 7 and 8.

REVIEWS.

THE HOME MARKET.

A handbook of statistics, by Major G. Harrison and F. C. Mitchell and the statistical staff of the London Press Exchange Limited, *George Allen & Unwin, Ltd.*, London, 1936. pp. 149, price 10*s*.

This handbook, as indicated in the Introductory Review, has been compiled from figures accumulated in the course of market research, and presents some of the most important statistical data concerning the British Public. It is rightly pointed out that considerable ground remains to be covered in the official collection of the most fundamental information, and progress is hampered by an unstandardized nomenclature, the variation in efficiency of methods of computation, and the diversity of sources from which data must be culled. It is with the object of making a start in the provision of such information in a single volume that the present handbook has been prepared.

The statistical summaries are divided between twenty-one sections of approximately four pages each. Fourteen are concerned with the distribution of the population over various grouping units. Purchasing power, the incidence of poor relief, and distribution of labour in industry receive a section each, while finance is dealt with in four sections on distribution of incomes, one year's national expenditure, earnings in certain main industries, and expenditure of sample families. The final section is devoted to a study of the regional distribution of the Daily and Sunday Press.

In a book of this kind it is essential that the data should be computed in a way which gives results representative of the actual state ot affairs rather than of theoretical conditions. Appendix B, at the end of the book, gives an outline of the methods used in obtaining the information given in earlier pages. The sources from which the compilation was made are given at the head of each section.

The format of the book is pleasing. Twenty-seven tables are given together with ten full-page diagrams, six maps, and two charts, printed in various colours. Yet it is perhaps on this point that a doubt arises whether the present layout is that most suitable for a work which, if enlarged and supplemented as information accumulates, might take its place as a standard book of marketing statistics. At present the spacing of the text (about four lines of type to the inch) would appear too lavish, and the colourful diagrams might well be condensed to something less than their present size, and lose thereby nothing of their attractiveness. A book with such authoritative authorship, compiled primarily for strictly utilitarian purposes, might be more acceptable in the severer design of a scientific text-book, with the price made commensurate with the amount of data provided—for to the average buyer the appeal of such a book lies almost entirely in the quantity of accurate facts which it contains.

The above comment is largely based on a presumption that the accumulation of statistical data will ultimately necessitate an enlarged edition, or another book of similar aim. From this it may be inferred that the present volume is well worthy of more than passing attention. Within its own commercial sphere the book should prove extremely useful—perhaps not least as a means of stimulating further work in this field. Its contents can hardly fail to arouse interest: even the most casual perusal is rewarded with surprises (especially on such every-day matters as the distribution of the Press), while a careful comparison of figures graphically reveals the vicissitudes of the national fortunes in the last few years. At the conclusion of their introductory remarks the authors state that "The Home Market is only a beginning". In providing such authoritative material, supplemented with an account of the methods used in obtaining it, and a classified bibliography of sources of current statistical information, they have made an auspicious start, and deserve every congratulation.

R. G. F.

* * *

A PRACTICAL COURSE IN AGRICULTURAL CHEMISTRY.

By F. Knowles and J. E. Watkin, *Macmillan & Co., Ltd.*, London, 1937, pp. 188, price 10*s*.

This book is a laboratory guide for senior students of agriculture, dairying, horticulture and poultry husbandry. The authors are lecturers in the East Anglian Institute of Agriculture, Chelmsford, England, and the scope of the work is that usually covered in British agricultural colleges offering the B.SC. degree or diploma in agricultural sciences. The treatment is elementary, and the explanations of the processes performed aim at demonstrating the bearing of the subject on farm practice. There are seven chapters dealing respectively with soils, manures, biochemistry, feeding-stuffs, dairy products, water and insecticides and fungicides. The laboratory exercises are carefully selected after long testing in the authors' classes. They are amplified by brief discussions of the subjects they are intended to illustrate; many of them are quantitative.

Perhaps the least satisfactory section of the book is that on soils, but it is notoriously difficult to design really instructive class experiments that adequately illustrate the science of the soil. Thus, the reviewer fails to see why the time-honoured flocculation experiments with dilute aqueous suspensions of clay soil should be accepted as illustrating any valuable field property of soil; experiments on crumb structure would have been much more instructive. The value of mechanical soil analysis also appears to be somewhat overstressed. The very important properties of soil organic matter are almost entirely ignored. The ideal laboratory manual on soils is yet to be

compiled; such would doubtless present soil science in its ecological aspect, that is, it would demonstrate the relationships between the physics and chemistry of the soil and the behaviour of the growing plant.

Fertilisers and manures are treated adequately and clearly, but the experiments described in this section are mainly quantitative. The chapter on biochemistry is treated in a very elementary fashion; lack of space has obviously greatly limited the authors' scope. Perhaps the best chapters in the book are those dealing with feeding-stuffs and dairy products, particularly milk, which is very fully considered. The remaining chapters appear to be adequate.

The book is beautifully printed, and the different sections are neatly arranged. The descriptions of the experiments are clear and concise; they amply meet the needs of students working alone without supervision.

F. H.

* * *

COMPOSTING TEA ESTATE WASTES.

By A. G. D. Bagot. *The Times of Ceylon Co. Ltd.*, Ceylon, 1936, pp. 24 + xvi. 6*s.* 0*d.* (Rs. 4.00).

This little booklet describes in clear and simple language the modifications in the original Indore process as elaborated by Howard, which the author suggests as a result of experiments that have been carried out by the Nuwara Eliya Tea Estates Co. Ltd. Mr. Bagot is a whole-hearted adherent of composting, but from the warmth with which he advocates the adoption of a composting system, it may be guessed that his views are not universally accepted. The whole question is under careful investigation by the Tea Research Institute, for it is evident that with a perennial crop like tea, the value of using a ready-made humus manure may have little advantage over the practice of forking in green manure, as at present adopted on most estates, and what advantage it has, may be easily offset by the extra cost. More experience is wanted, and for those who wish to carry out their own experiments this little book would be useful, were its price more reasonable, for to ask Rs. 4 (6/-) for a paper-covered pamphlet is preposterous.

The author might note for future publications, that the Journal of the Tea Research Institute is called the *Tea Quarterly*, not the Tea Research Institute Journal.

R. C. W.

* * *

FOSSILS.

WHAT THEY TELL US OF PLANTS AND ANIMALS OF THE PAST, by R. S. Lull, PH.D., SC.D., *Chapman & Hall Ltd.*, London, 1936. pp. 114, price 4*s.* 6*d.*

Fossils constitute all the documentary evidence we have concerning the character and evolution of plants, animals and man. It has been the object of the writer of this book to describe the fossil evidence and the conclusions that can be drawn therefrom. Among the various topics considered are the nature and appearance of fossils, the means whereby the age of fossils is determined by the geologist, the more famous localities of the earth where some outstanding fossil forms have been found, the theory of evolution based on fossil evidence, and the characteristic fossils of the great geological periods. Special chapters are devoted to fossil horses, elephants and man. The concluding chapter deals with the utilitarian value of fossils as indices of coal-bearing and oil-bearing strata. A reading list, a glossary and an index to the subject matter complete the book. As a comprehensive and eminently readable account of fossils, Professor Lull's book can be strongly recommended to students interested in the broader aspects of palaeontology. It is not a mere catalogue of fossil names, such as frequently repels the beginner, but an interesting discussion of a subject which invariably appeals to the average reader in search of general information. The numerous drawings and photographic reproductions form a valuable asset.

F.H.

* * *

STUDIES IN SUGAR-CANE II.*

By T. Varahalu, *The Scholar Press*, Palghat, 1936, pp. 394-417.

This article is a critical study of the differential effect of climate and age on the growth and composition of the sugar-cane crop in the Madras Presidency. Some fourteen varieties of cane, each tried out at twelve dates of planting at monthly intervals and on six research stations, were tested. Analyses of the canes in each treatment and variety were made at periodic intervals, and in addition, data on the weight, length, girth and number of internodes of the canes were collected, so as to provide a comprehensive picture of the development and condition of the crop on any particular date. A formidable mass of data has been accumulated, and is recorded in ten pages of tables at the end of the article. With a crop as difficult to sample as sugar-cane, a brief discription of the sampling method and some estimate of the experimental error might have been included with advantage. In the text, the author gives a careful analysis of the data and discusses their exact significance in determining the correct date of planting and harvesting the sugar crop at the different centres under observation. Where such a wide field of research is covered in relatively small compass, it is not to be wondered at that the report is rather complex. However, the text is amply supported by diagrams, and these effectively summarise the data and illustrate the various points discussed. Inferior reproduction and poor quality paper detract considerably from the value of these diagrams, which are otherwise excellent. A detailed summary of results concludes a very interesting survey of a really complex and important aspect of cane cultivation and sugar extraction.

D. D. P.

* A reprint from *The Madras Agricultural Journal* Vol. XXIV, No. 11, 1936.

SANDS, CLAYS AND MINERALS.

Published by *A. L. Curtis*, Chatteris, England, Price 3*s*. 6*d*.

This magazine was reviewed in *Tropical Agriculture* Vol. XIII, 1936, on page 145, but recently it has been issued as an enlarged publication (Vol. III, No. 1, Nov. 1936), containing 76 pages and 29 illustrations. Among the articles especially interesting to agriculturists and plant physiologists included in this number is a description of the technique and results obtained in a study of the phosphate nutrition of lettuce in pure silica sand cultures treated with complete nutrient solutions containing graded amounts of phosphate, written by Dr. R. M. Woodman of the Cambridge University Horticultural Research Station. Another important contribution is a brief descriptive account of certain aspects of soil science, written by Professor G. W. Robinson of Bangor University, North Wales. Other articles deal with nickel in Canada, the mineral resources of Brazil and of Tanganyika, industrial water supply, and the barytes deposits of Greece.

An editorial note, entitled "Great Empire Builders" refers to the invaluable work done on behalf of Empire development by His Majesty King Edward VIII and by General Smuts, and discusses the usefulness of an Imperial Development Board such as has been advocated by Sir Robert Hadfield. The idea behind this Board is to encourage the extension of Empire resources by means of exploration, co-ordination of information, and direction of capital to schemes of exploitation. The Board would consist of technically-qualified men who would travel to every part of the Empire in turn where permanent secretariats would eventually be established. Besides the discovery of new supplies of raw materials, including minerals, the Board would aid in improving transport facilities, the construction of docks and aerodromes and of irrigation schemes. It is believed that the Board's activities would help to remove disturbing trade fluctuations, and to solve many present economic problems.

F. H.

* * *

MACHINERY AND EQUIPMENT OF THE CANE SUGAR FACTORY.

L. A. Tromp. *Norman Rodger* 30*s*. Royal 8vo. 644 pages. 616 Line Illustrations. 133 Plate Illustrations. Buyers' Guide.

The Sugar Industry has at last a standard textbook devoted entirely to its machinery and equipment. We would at the outset wish to congratulate Mr. L. A. Tromp on the exceedingly high standard which he has maintained throughout and Mr. Rodger on the excellent reproduction of drawings and photographs. The book embraces every aspect of the theory and practice of sugar factory equipment. The data have been collected we are told, during the author's 20 years experience of consulting, designing and operating practice. Each of the 37 chapters is devoted to a separate subject and the treatment is ample. All the line drawings have been made specially for the publication by the author himself. One feels that there is justification for such painstaking care. Almost every page or paragraph contains information, not only useful but vital to the industry for efficient factory operation. We wish this book every success and feel that it will take its place beside the "classics" of Deerr, Geerligs, Webre, Maxwell and others.

J. G. D.

THE CACAO INDUSTRY OF TRINIDAD.—*Continued.*

SOME ECONOMIC ASPECTS.

Series II.—A financial survey of estates during the seven years 1923-4 to 1929-30.

By C. Y. Shephard.

PART V.—COMPARISON OF VARIOUS GROUPS OF ESTATES.

SECTION (*b*).—COMPARISON OF ESTATES GROUPED ACCORDING TO AREA UNDER CACAO CULTIVATION (*See* Table VII and Figs. XXVI to XXXI).

Cost of Production and Profits (*See* Figs. XXVII, XXX and XXXI).

The suggestion made in Part IV and Section (*a*) that abnormally large and small estates are sub-normal in efficiency is confirmed by a comparison of estates grouped according to size. Thus, of the five size groups ranging from less than 150 to 550 or more acres of cacao, those of 300 acres are most efficient, and each increase or decrease in size is accompanied by an increase in the cost of production and a decrease in profits. For example, the cost of production per bag of cacao rises from \$11.07 (£2 6*s*. 1½*d*.) on estates of 300 acres, to \$13.61 (£2 16*s*. 8½*d*.) on those of less than 150 acres, and to \$14.55 (£3 0*s*. 7½*d*.) on those of 550 or more acres. The profit per acre of cacao diminishes from \$12.23 (£2 10*s*. 11½*d*.) on the 300-acre estates, to \$7.79 (£1 12*s*. 5½*d*.) on the smallest estates, and to \$5.76 (£1 4*s*. 0*d*.) on the largest estates.

Expenditure (*See* Figs. XXVI and XXVIII).

The total expenditure per acre ranges from $23.20 (£4 16*s.* 8*d.*) on the smallest estates to $17.84 (£3 14*s.* 4*d.*) on the largest estates. Estates of 450 acres spend more than those of 300 acres, but otherwise each increase in size of estate is accompanied by a decrease in the total expenditure on cacao. The 300-acre estates, however, spend least on cultivation, and in each smaller and larger size class there is a progressive increase in expenditure, the smallest estates being the most intensively cultivated. The expenditure on management and supervision is notably high ($6.02 or £1 5*s.* 1*d.* per acre) on the smallest estates, but diminishes through successive size classes to $3.54 (14*s.* 9*d.*) per acre on the largest estates.

Yields (*See* Fig. XXIX).

The largest estates give the lowest yields, namely, 202 lb. of cacao per acre (4.55 bags per 1,000 pickets). Between the four remaining size classes there is very little difference in yield. The 300-acre class obtained the highest yield (283 lb. per acre, or 6.45 bags per 1,000 pickets), but was followed very closely by the smallest estates which gave 281 lb. per acre (5.94 bags per 1,000 pickets). Yields in the 450-acre class averaged 273 lb. per acre (6.01 bags per 1,000 pickets), and those in the 200-acre class, 268 lb. per acre (5.54 bags per 1,000 pickets). Hence, there is a range of only 17 lb. of cacao per acre in the first four size classes, but a difference of $4.44 (18*s.* 6*d.*) in profit per acre.

Subsidiary Crops (Items 23, 32 and 33, Table VII).

The revenue from crops interplanted with cacao is least on 300-acre estates, and each increase and decrease in size of estate is accompanied by an increase in revenue from this source. The 300-acre estates also spend least on separate areas of crops other than cacao. Nearly 99 per cent. of their total expenditure is on, and nearly 98 per cent. of their total revenue is from, cacao. Each larger and smaller size class of estates is accompanied by diminished dependence on cacao. The largest two size classes incurred losses on subsidiary crops, whereas every other class earned profits. There is a possibility that the crops now under trial on the largest estates may prove less profitable than cacao.

Mortgages (Item 39, Table VII).

The 300-acre estates are the most heavily mortgaged, and pay $3.11 (12*s.* 11½*d.*) for each acre of cacao in interest. The next larger size class pays $2.14 (8*s.* 11*d.*), and the next smaller $1.68 (7*s.*) per acre in interest. The largest estates pay by far the least in interest, namely, 75 cents (3*s.* 1½*d.*) per acre. The smallest estates, on the other hand, pay $2.56 (10*s.* 8*d.*) per acre, or the second highest amount in interest.

Size and Efficiency.

The 300-acre class is the most profitable. This size probably represents the optimum for efficient control by a resident manager. On larger estates, some delegation of the managerial functions to competent subordinates is necessary. On smaller estates, the employment of a first class manager constitutes a heavy charge on each acre of cacao. The smallest estates are intensively cultivated and give good yields, but overhead charges are high; hence, although their gross revenue is large, their net income is small. The aggregation of such units into ones of about 300 acres would probably result in greater efficiency by spreading the burden of overhead charges. It is doubtful, on the other hand, whether the division of the largest estates into units of 300 acres would lead to any improvement in efficiency. It has been noted that they pay less than half the interest on mortgages of any other group, have experimented with manures, and rely to an appreciable extent on intercultivated and subsidiary crops. These factors are associated, during the period under review, with unfavourable natural conditions. The largest estates were, at one time, heavily mortgaged, but the failure to maintain regular payments of interest led, in most instances, to the mortgagees taking possession. These estates consisted originally of much smaller estates but were gradually consolidated into their present size by foreclosures. Had they been more efficient they would have maintained their existence as smaller estates. It is more correct to say that these estates are large because they are poor, than that they are poor because they are large. The 300-acre estates exhibit those characteristics associated with favourable natural conditions, namely, good yields despite low expenditure on cultivation, no purchase of manures, and an almost exclusive reliance upon a single crop. Thus, the differences in efficiency between the size groups can be attributed, in large measure, to factors unconnected with their size, except that the smaller estates would probably benefit by spreading overhead charges over a larger area.

Summary.

The 300-acre estates earned the largest profits and this size appears about the optimum for efficient control by a resident manager. There is, however, little difference in yields between the four groups less than 550 acres in area, while the largest estates appear to be handicapped by conditions not necessarily connected with their size. Thus, although the small estates would probably benefit from reduced overhead charges per acre and per bag of cacao by being increased in size, little improvement would be effected by subdividing the large estates. There appears, then, to be little relation between the size of estates and their efficiency.

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO AREA UNDER CACAO CULTIVATION, 1923-4 TO 1929-30

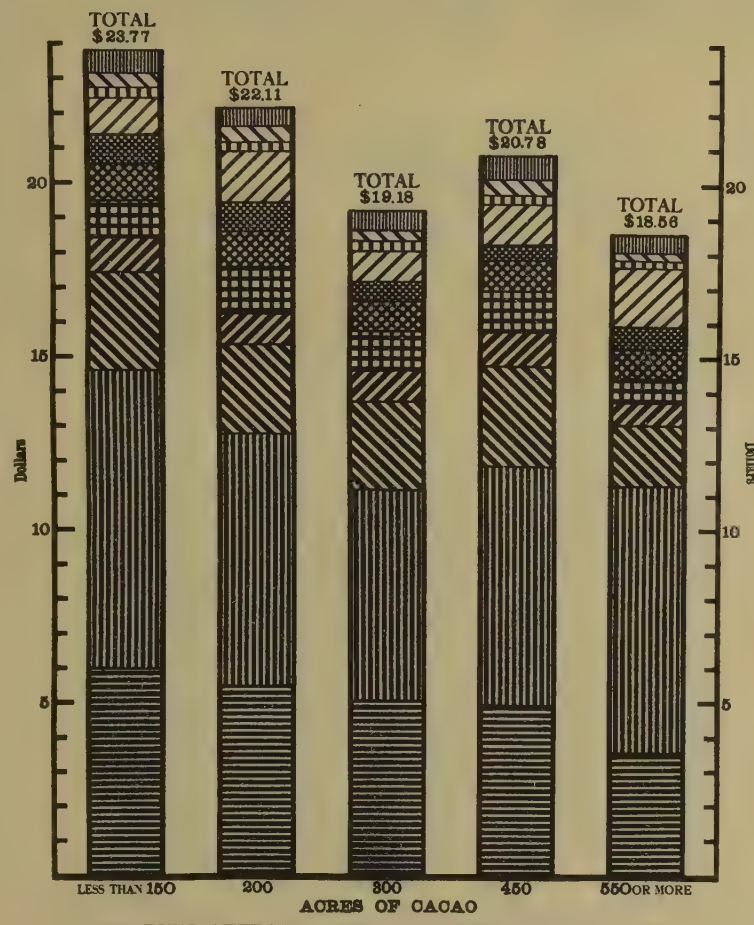


FIG. XXVI. AVERAGE ANNUAL EXPENDITURE PER ACRE

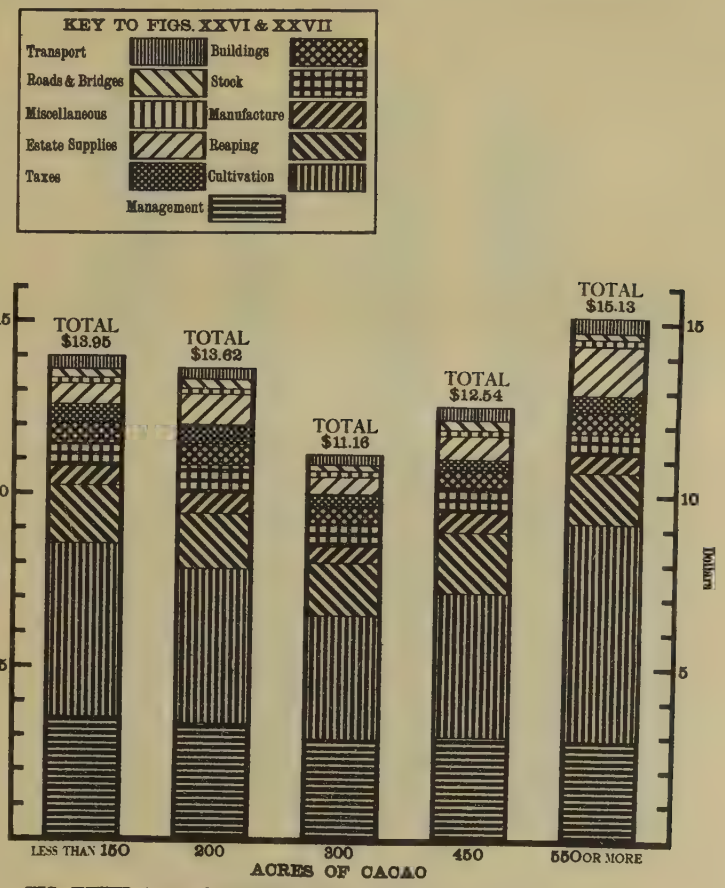


FIG. XXVII. COST OF PRODUCTION PER BAG (165 lb.) OF CACAO

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO AREA UNDER CACAO CULTIVATION, 1923-4 TO 1929-30

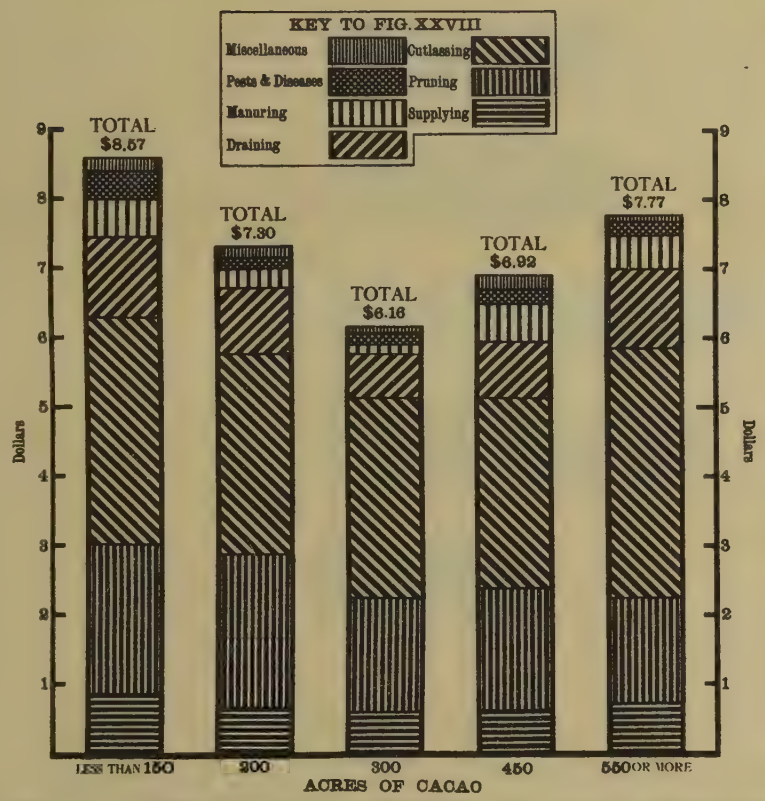


FIG. XXVIII. AVERAGE ANNUAL EXPENDITURE PER ACRE ON CULTIVATION

FIG. XXIX. AVERAGE ANNUAL YIELD PER ACRE

COMPARISON OF TRINIDAD CACAO ESTATES IN SIZE GROUPS, 1923-4 TO 1929-30.

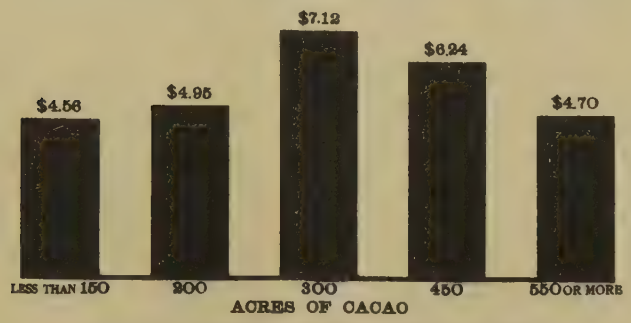


FIG. XXX. PROFIT PER BAG (165 lb.) OF CACAO

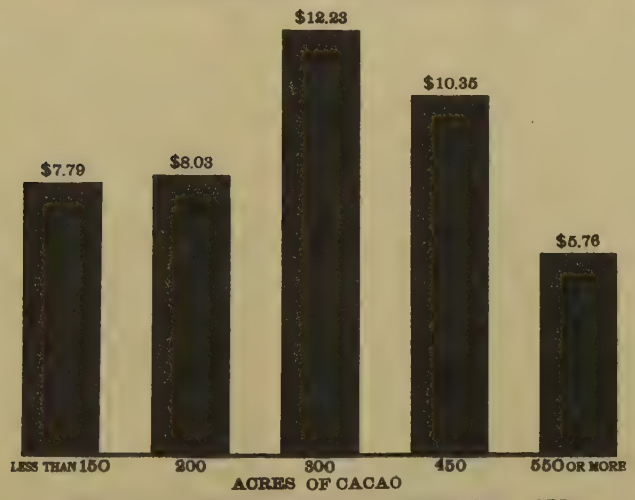


FIG. XXXI. AVERAGE ANNUAL PROFIT PER ACRE

Table VII.—Analysis of the Expenditure, Revenue, &c., of 126 Trinidad Cacao Estates grouped according to **SIZE OF ESTATES** for the Seven financial years 1923-4 to 1929-30.

No.	Item. Description.	Expenditure per Acre of Cacao. Size of Estates in Acres. Under 150	200	300	450	550 or more.	Cost Per Bag (165 lb.) of Cacao. Size of Estates in Acres. Under 150	200	300	450	550 or more.	Item No.
		$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	
1	Management and Supervision	6.02	5.45	4.99	4.92	3.54	3.53	3.36	2.91	2.97	2.88	1
	Cultivation:											
2	"Supplying" Cacao Trees ..	.86	.66	.59	.65	.72	.51	.40	.34	.40	.59	2
3	Trimming and Pruning Trees	2.16	2.22	1.67	1.77	1.53	1.27	1.37	.98	1.07	1.25	3
4	Cutlassing and Weeding ..	3.27	2.88	2.87	2.75	3.61	1.92	1.77	1.67	1.66	2.94	4
5	Draining and Roundridging	1.15	.95	.64	.81	1.15	.67	.59	.38	.49	.94	5
6	Applying Manure ..	.55	.27	.14	.54	.47	.32	.17	.08	.32	.38	6
7	Pests and Diseases ..	.39	.16	.16	.20	.20	.23	.10	.09	.12	.16	7
8	Miscellaneous Cultivation ..	.19	.16	.09	.20	.09	.11	.10	.05	.12	.07	8
9	Total Cultivation ..	8.57	7.30	6.16	6.92	7.77	5.03	4.50	3.59	4.18	6.33	9
10	Reaping	2.86	2.56	2.57	2.91	1.79	1.68	1.58	1.49	1.76	1.46	10
11	Manufacture	.95	.89	.88	.99	.63	.56	.55	.51	.59	.52	11
12	Live Stock	1.11	1.35	1.14	1.15	.71	.65	.83	.66	.69	.58	12
13	Buildings	1.06	1.04	.87	.92	.83	.62	.64	.50	.55	.68	13
14	Taxes	.84	.83	.56	.43	.54	.49	.51	.33	.26	.44	14
	Estate Supplies:											
15	Manures	.02	.03	..	.02	.29	.01	.02	..	.01	.23	15
16	Feed	.27	.47	.32	.56	.48	.16	.29	.19	.34	.39	16
17	Other	.74	1.01	.57	.59	1.03	.43	.62	.33	.36	.84	17
18	Total Supplies	1.03	1.51	.89	1.17	1.80	.60	.93	.52	.71	1.46	18
19	Miscellaneous	.29	.22	.28	.25	.21	.17	.13	.16	.15	.17	19
20	Roads and Bridges	.39	.45	.29	.47	.24	.23	.28	.17	.29	.20	20
22	Total Cost	23.12	21.60	18.63	20.13	18.06	13.56	13.31	10.84	12.15	14.72	22
23	Revenue from Inter-cultivated crops	.57	.45	.16	.35	.72	.34	.28	.09	.21	.59	23
24	Cost on Estate	22.55	21.15	18.47	19.78	17.34	13.22	13.03	10.75	11.94	14.14	24
25	Transport to Merchant's Store	.65	.51	.55	.65	.50	.39	.31	.32	.39	.41	25
26	Cost at Merchant's Store ..	23.20	21.66	19.02	20.43	17.84	13.61	13.34	11.07	12.33	14.55	26
29	Revenue from Cacao ..	30.99	29.69	31.25	30.78	23.60	18.17	18.29	18.19	18.57	19.25	29
30	Profit on Cacao	7.79	8.03	12.23	10.35	5.76	4.56	4.95	7.12	6.24	4.70	30
31	Loss on Cacao	..	..	..	..	..	..	..	..	..	..	31
32	Other Expenditure	3.42	3.23	.28	1.57	3.32	2.00	1.99	.17	.94	2.71	32
33	Other Revenue	5.55	6.05	.70	1.41	2.66	3.26	3.73	.41	.85	2.17	33
34	Total Expenditure	26.62	24.89	19.30	22.00	21.16	15.61	15.33	11.24	13.27	17.26	34
35	Total Revenue	36.54	35.74	31.95	32.19	26.26	21.43	22.02	18.60	19.42	21.42	35
36	Profit	9.92	10.85	12.65	10.19	5.10	5.82	6.69	7.36	6.15	4.16	36
37	Loss	..	..	..	..	..	..	..	..	..	..	37
38	Interest Received	.02	.05	.02	.01	.01	.01	.03	.01	.01	.01	38
39	Interest Paid	2.56	1.68	3.11	2.14	.75	1.50	1.04	1.81	1.29	.61	39
40	Net Profit	7.38	9.22	9.56	8.06	4.36	4.33	5.68	5.56	4.87	3.56	40
41	Net Loss	..	..	..	..	..	..	..	..	..	..	41
		Total.					Average.					
42	Cacao Acreage	4,493	6,754	6,924	7,265	6,784	96	199	301	454	1,131	42
43	No. of Cacao Pickets in 1,000's	1,290	1,979	1,844	2,003	1,829	27	58	80	125	305	43
44	Valuation in 1000's $ ..	1,564	1,795	1,480	1,633	1,194	33	53	64	102	199	44
45	Yield in bags of Cacao ..	7,660	10,959	11,893	12,039	8,318	163	322	517	572	1,386	45
46	Yield in bags per 1,000 pickets	..	..	..	..	..	5.94	5.54	6.45	6.01	4.55	46
47	Yield in lb. per acre	..	..	..	..	..	281	268	283	273	202	47
48	Yield in lb. per picket ..	..	..	..	..	..	.98	.91	1.06	.99	.75	48
49	Price of cacao per fanega in $	..	..	..	..	..	12.11	12.20	12.13	12.38	12.83	49
50	Per cent. return on capital ..	..	..	..	..	..	2.85	4.08	5.92	4.53	2.90	50
51	No. of estates surveyed ..	47	34	23	16	6	..	..	..	..	..	51

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Vacuum Control in the Sugar Factory.—*By J. H. Dick.*

Taking the case of a vacuum pump common to a number of pans, the usual method is to use an auxiliary pump as a booster for bringing a pan up to full vacuum before switching on to the main pump line. If the sugar-boiler is in a hurry and switches a pan from the booster to the main too early, the vacuum throughout the system is suddenly lowered, may be ½ to 1 in., and then only gradually returns to normal value. In fact any of the several causes of an alteration in vacuum occurring at one pan, such as a feed tank emptying and allowing air to be drawn in through the feed lines, affects the whole vacuum system.

Variations caused by the common injection water-main system are even more serious. Unless the pressure in the water main is considerably greater than enough to first supply the water required when the vacuum is broken on one pan, the injection water stops flowing through its condenser, and the head on the others, and consequently their water flow, is increased. This increases the vacuum. When the pan comes back on the line again the reverse happens. In fact, when any alteration to the flow of injection water is made to one condenser for such purposes as graining, &c., an alteration in flow occurs throughout, with consequent vacuum variations.

At Kalamia there is one vacuum pump evacuating six pans and a set of effects, and the seven condensers are supplied with water from a common main. Vacuum variation has been so considerable in the past that during the 1935 season an investigation was made into the possibilities of automatic vacuum control.

The original idea was to control the injection water according to the leg pipe temperature. With this in view, a Kent air-operated temperature controller was installed on the low grade pan, the mercury-in-steel thermometer of the controller being inserted in the leg pipe of the condenser, and the 8-inch butterfly type diaphragm controlled valve in the injection water line.

By this means a steady leg pipe temperature was attained, but the vacuum was not sufficiently steady. To overcome this, the thermometer was placed in a pot of water kept boiling at the vacuum in the pan. This is actually a measure of vacuum.

Further experiments were carried out at the effects. A bi-metallic strip type of temperature controller was tried out in the leg pipe in conjunction with a 6-inch air-operated diaphragm controlled valve in a by-pass in the injection water line. This could not be made sufficiently sensitive, however, and was discarded. It was also obvious from this attempt that controlling a 6-inch by-pass did not offer sufficient range to cope with the variations which occurred.

After this the 6-inch valve and a 10-inch air-operated diaphragm steam valve were placed in parallel in the injection water line and were jointly controlled by a vacuum controller built on the job. This was constructed from an indicating vacuum gauge on the opposite nozzle principle used by the Kent instruments, and controlled the valves directly according to vacuum. This installation, whilst definitely experimental in nature, definitely showed the possibilities of vacuum control which this arrangement offers.—(*Int. Sugar Jr.* Vol. XXXIX, No. 457, p. 33, 1937.)

* * *

New Alcoholic Fermentation Process. *By J. Courtois.*

According to the Gay-Lussac equation, 100 kg. of glucose should yield 51 kg. of absolute alcohol equal to 64.34 litres. But in practice this theoretical yield is at most 61.1 litres. In practice, 60 litres is considered a very good yield. The difference between theory and practice is more than 6 per cent.

But in the new "yeast recovery process" of the Usines de Mell the fermented wort is passed through a centrifuge which extracts the yeast; the yeast is then immediately returned to a fresh batch of wort equal in volume and concentration to the previous wort. When the new wort has been fermented the extraction of the yeast is repeated, and so on indefinitely.

Under these circumstances there is very little multiplication of the yeast cells; most of their energy goes towards the production of alcohol, and the yield is raised from 3 to 6 per cent. It is said that no trouble is experienced from bacterial contamination. The advantages are a considerable increase in the capacity of existing distilleries or a reduction of the first cost of a new plant of given capacity; the time of fermentation is considerably shortened.—(*Inter. Sugar Journal*, Vol. XXXVIII, No. 453, p. 355, 1936.)

* * *

Bibliography on Soils and Fertilizers. *By O. Schreiner.*

The Committee on soils of the International Society of Sugar Cane Technologists has assembled a bibliography of soil and fertilizer literature relating to sugar-cane, and comprising publications in the three-year period 1931-1933, supplementing the previous bibliography covering the period 1921-1930. This bibliography contains 475 references by about 275 contributors. The chief interest still lies in field experiments (299 publications), soil examination by physical, chemical, and physiological methods (100 publications, of which 62 were chemical), and soil survey work (44 articles). Most of this work has been done in Hawaii, Java, Australia, India and Africa.—(*Facts about Sugar*, Vol. XXXI, No. 4, p. 150, 1936.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

A New Substitute for Glass.

A new water-clear plastic, strong as glass, flexible, and non-shattering will be introduced under the trade name of "Pontalite" by E. I. du Pont de Nemours & Company. A factory for making the plastic is under construction. Production is scheduled to begin this year.

This plastic, known to chemists as methyl methacrylate polymer, is only half as heavy as common glass. It is as clear as optical glass, and is so strong that it will resist a tension of 4 to 5½ tons a square inch.

Though softer than glass, the plastic is hard enough to be widely useful. It can be sawed, cut, turned, drilled and polished, and being thermoplastic, it can be moulded to any desired form. A liquid, intermediate variety can be poured into moulds and hardened, and in this way castings are made readily. Unlike glass, it transmits a large proportion of the sun's ultra-violet light. It is, moreover, unaffected by sunlight, and in general is not affected by other destructive elements.

"The transparency, brilliance, strength, and permanence of 'Pontalite' are unusual", says Dr. Dittmar, "and the absence of colour permits fabrication into delicate tinted shades. By combining dyes and pigments, varying degrees of colour and transparency can be obtained. The value of the plastic is enhanced by the ease with which it can be worked, and the crystal-like transparency indicates many uses where strength, lightness, and ultra-violet transmission are desired".

Dr. Dittmar says further that solutions of the plastic, also the liquid intermediate form have been used successfully as impregnate for wood, cloth, paper, stone, and electrical apparatus. Materials treated in this way are much more resistant to water, oils, and chemicals. For example, when wood is treated with the plastic, the strength is increased, as is resistance to water absorption, warping, and the action of chemicals. Though "Pontalite" can be burned, it is not flammable in the ordinary sense; it is definitely a "safety" plastic. Many chemical variations of the plastic can be produced, having a wide range of properties. all the way from hard, heat-resistant solids to heavy viscous liquids.—(*Agricultural News Letter*, E. I. du Pont de Nemours & Co., Vol. IV, No. 10, pp. 142-43, 1936.)

* * *

Phosphatides in Soybean Oil.

In the agricultural laboratories of the Purdue University, Indiana, previous results showing that the phosphatides can be removed from crude soybean oil by emulsifying it with water and centrifuging or filtering, have been confirmed. It has also been shown that these phosphatides are responsible for the "break" of crude soybean oil. A process for extracting phosphatides to produce a "non-break" oil has been devised. The effect of varying the temperature and water content on the yield and composition of the phosphatides has also been determined. During storage, the phosphatide content of the upper layers of the oil diminishes, while in the lower layers it increases. It has also been shown in the same University that soybeans contain a factor which, when the beans are introduced into the rations of dairy cows, has a suppressing action on the formation of vitamin *A* in butter. This factor is not affected by heat; it is found in the oil and in oil meal, but not in the alcoholic extract of ether extracted meal.

The term "phosphatides" or "lipoids" is synonymous with the more generally accepted term "phospholipins" which are "fat-like" substances playing an intermediary *rôle* in the process of fat utilization in the animal body. Lecithin is the best known of the phospholipins. Recently, in America, B. E. Horrall has made determinations of the lecithin content of various dairy products. In the fat of hens' eggs he found an average of 26.64 per cent. lecithin; the lecithin content of skim milk was 13.91 per cent. of the fat; raw sweet cream contained 0.428 per cent. lecithin in the fat.—(*Food*, Vol. VI, No. LXI, pp. 27-8, 1936.)

* * *

Destruction of Banana Plants.

Economical destruction of banana plants was not obtained by applying either power kerosene, light gas oil, Diesel oil or heavy Diesel oil to the soil immediately around the plants or to the plants themselves. The oils were most effective when they were applied in direct contact with the corms suckers and eyes. The lighter oils seemed to be somewhat more effective than the heavier oils.—(H. E. Eastwood in *Agr. Gaz. N.S. Wales*, 47, 193-9 (1936); Abstr. *Chem. Abstr.*, Vol. XXX, No. 17, 1936, p. 6118.)

* * *

Studies on the Coconut Palm; III. Coconut Husk. (A) The Manurial Value of Coconut-Husk Ash.

Complete analysis of the husk ash is given. It contains potassium 35 and phosphate two per cent. Approximately 50 per cent. of the potash was leached from husks exposed to heavy rains. Husks from trees grown on loamy soils contained 50 per cent. more potassium than those from trees grown on gravelly soils.—(M. L. M. Salgado, in *Tropical Agriculturist* (Ceylon) 86, 131-8 (1936); *Chem. Abstr.*, Vol. XXX, No. 18, 1936, p. 6497.)

* * *

Table Oil Produced from Tobacco Seeds.

Experiments show that table oil of first quality can be pressed out of tobacco seeds. The Hungarian Tobacco Monopoly has already signed contracts with several large oil factories to use their tobacco seeds, which have formerly been regarded as waste.—(*Ind. & Eng. Chem.; News Ed.*, Vol. XIV, No. 22, p. 450, 1936.)

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.)

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
31st December	5	6¾	9	3¾
7th January	5	8¼	9	5¼
14th January	6	6¾	10	0
21st January	5	10½	9	7½
28th January	6	3	9	11¼
4th February	6	0	9	8¼
11th February	6	1½	9	9
(13*th February*, 1936)	4	10½	8	6¾

A very firm and active tone has prevailed in spite of considerable fluctuations in prices due to profit taking and heavy stop loss selling. Raws have been in request but offers are scarce and sellers reserved. There is a distinct improvement in market sentiment which is not only confined to the United Kingdom, but which is also reflected in reports from all important sugar centres. During the coming campaign, the Cuban Government has fixed production at 2,939,000 tons.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:

	American Mid.	*Egyptian F.G.F. Sakel.*
31st December	7.10	10.40
8th January	7.11	10.25
15th January	7.20	10.26
22nd January	7.16	10.29
29th January	7.34	—
5th February	7.30	—
12th February	7.28	—
(14*th February*, 1936)	6.21	9.18

The American market has generally been quiet with prices still tending to rise. Prices of West Indian Sea Island remain firm, sales of Montserrat having been made at from 21*d.* to 24*d.*

* * *

COCOA.—During the latter part of last month sharp fluctuations on the New York Cocoa Exchange caused prices to decline and in consequence a weaker market was experienced. Manufacturers continue to do a good business and any real support given to the option market would bring about a resumption of the advance and would quickly change the entire situation.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

RUBBER.—Quotations for plantation sheet have ranged as follows:—

	Pence per lb
30th December	10 11-16
6th January	10 9-16
13th January	10 3-4
20th January	10 5-16
27th January	10 1-4
3rd February	10 3-8
10th February	10 1-2
(12*th February*, 1936)	7 1-4

Movements in the rubber market have been somewhat erratic, due to a large volume of outside buying and heavy profit taking, but the tone generally remains distinctly firm with prices at one time exceeding 11*d.* The main influences have been the strike in America, and the demand for near rubber which is in short supply, the United Kingdom stocks continuing to show a decrease. According to the *American Questionnaire* total consumption in the U.S.A. for 1936 worked out at 573,519 tons, as against 497,148 tons in 1935, an increase of 76,371 tons equal to something over 15 per cent.

* * *

COPRA.—Firm market with nominal value of West Indian f.m.s. at £24 15*s.* c.i.f. London.

* * *

BANANAS.—The demand has been fair, Jamaicas continuing unchanged at £17 5*s.* per ton delivered London, and £17 nearest station Provinces. Brazilians are £2 higher at £14 delivered London and £15 Provinces.

* * *

GRAPEFRUIT.—Jamaicas quoted at 8*s.* to 9*s.* per case. Trinidad prices ranged from 12*s.* to 14*s.* a case. For British Honduras, trade was very fair at prices from 14*s.* to 15*s.* a case. Some fruit of very fine quality realised 18*s.* per case.

* * *

COFFEE.—Kenya.—latest quotations per cwt., fair to good 75*s.* to 90*s.*; ordinary 58*s.* to 62*s.*; top price bold sizes 131*s.* 6*d.* Costa Rica:—bold sizes, from 53*s.* to 60*s.*; market for this coffee in much healthier position. Brazil:—Superior Santos 50*s.* 9*d.*; Rio 41*s.* 6*d.*